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OPERATOR'S INSTRUCTION BOOK

CINCINNATI

ML and MI MILLING MACHINES

★

Publication No. M-1944-1

This Booklet should be Filed in the Tool Crib and Issued by Tool Check only

MILLING MACHINE DIVISION
THE CINCINNATI MILLING MACHINE CO.,
CINCINNATI 9, OHIO, U. S. A.

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THIS book was written for operators of CINCINNATI® Nos. 203–10 ML, 205–10, 307–14 and 410–14 MI Plain and Universal and 205–10 MI Vertical Milling Machines.

At the time of writing, the book was completely up to date. However, due to continual improvements in design, it is possible that descriptions contained herein may vary to a slight extent from the machine delivered to you. This merely implies that the machine has been improved to better fulfill your requirements.

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ILLUSTRATION REFERENCE NUMBERS

For your convenience in quickly finding illustrations referred to in the text, we have given all illustrations the same number as the page on which they appear. For example, Figures 28A, 28B, and 28C are all on page 28.

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PATENT NOTICE

The machines and attachments illustrated and described in this book are manufactured under and protected by issued and pending United States and Foreign Patents.

* * *

The design and specifications of these machines are subject to change without notice.

* * *

SERIAL NUMBER

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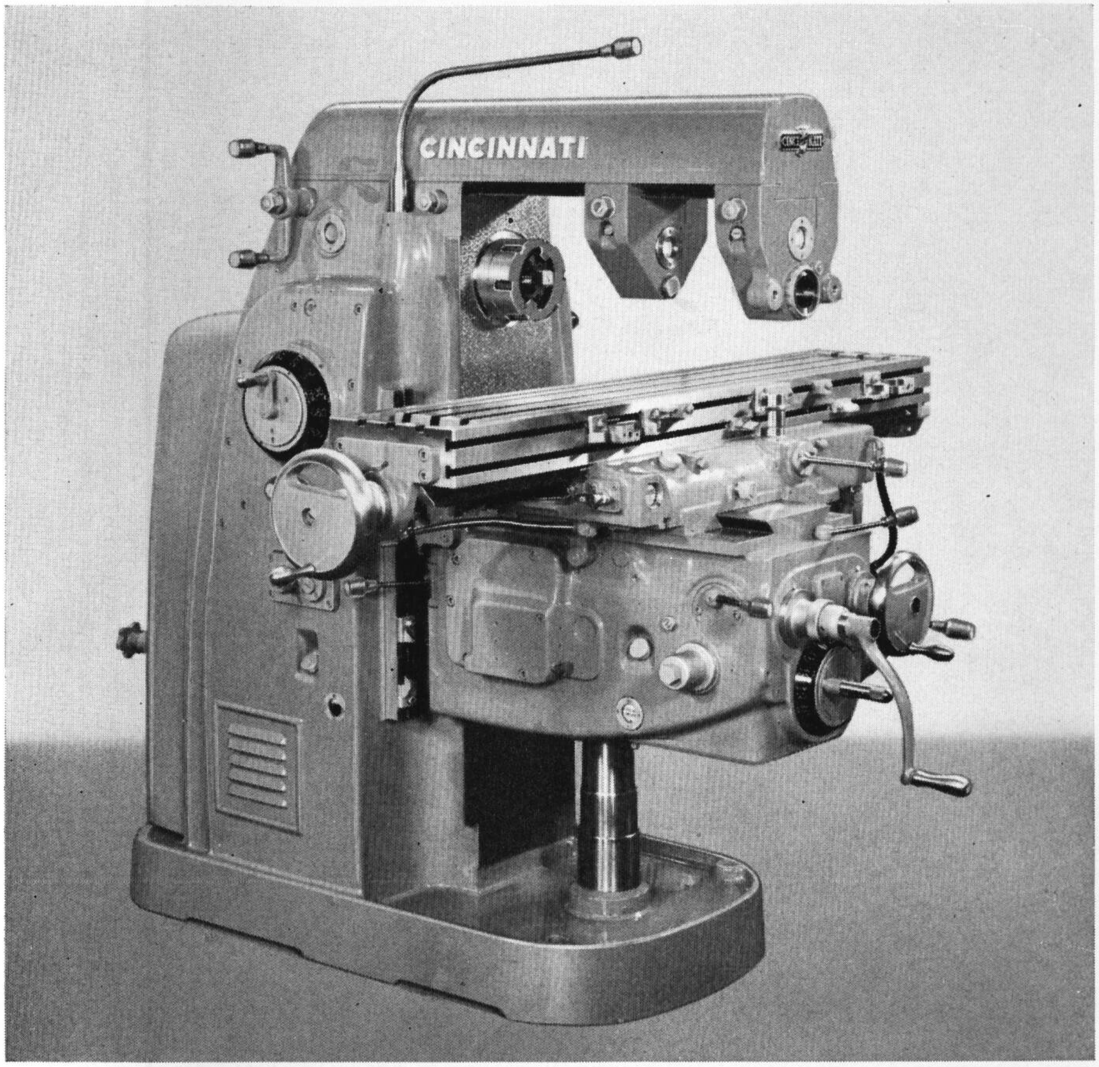


Figure 5A
CINCINNATI No. 205-10 MI Plain Milling Machine
(Nos. 203-10 ML and 307-14 and 410-14 MI Plain Machines
are identical in operating features)
(Automatic Table Cycle Available at Extra Cost)

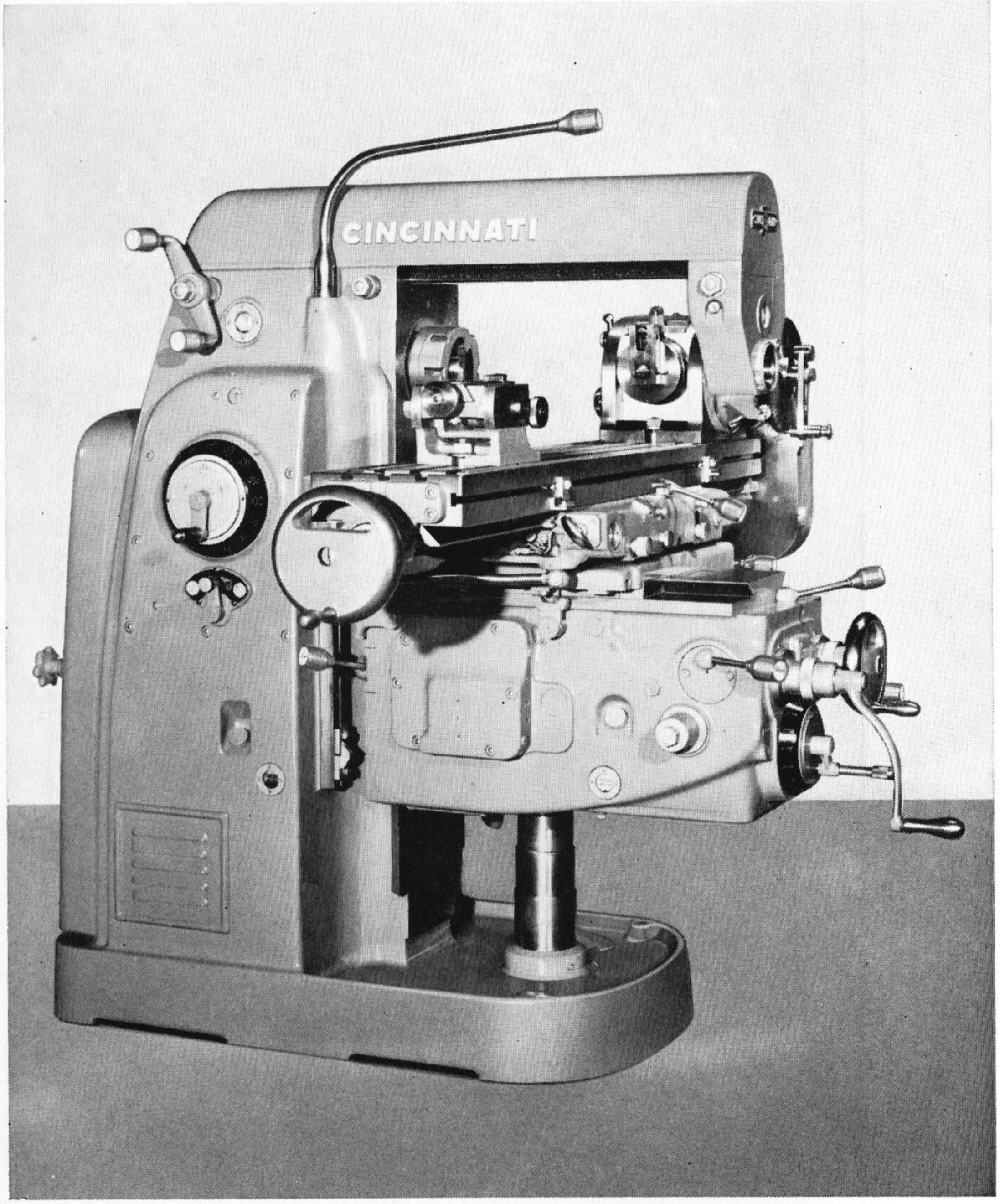


Figure 6A
CINCINNATI No. 205-10 MI Universal Milling Machine
(Nos. 203-10 ML and 307-14 and 410-14 MI Universals
are identical in operating features)

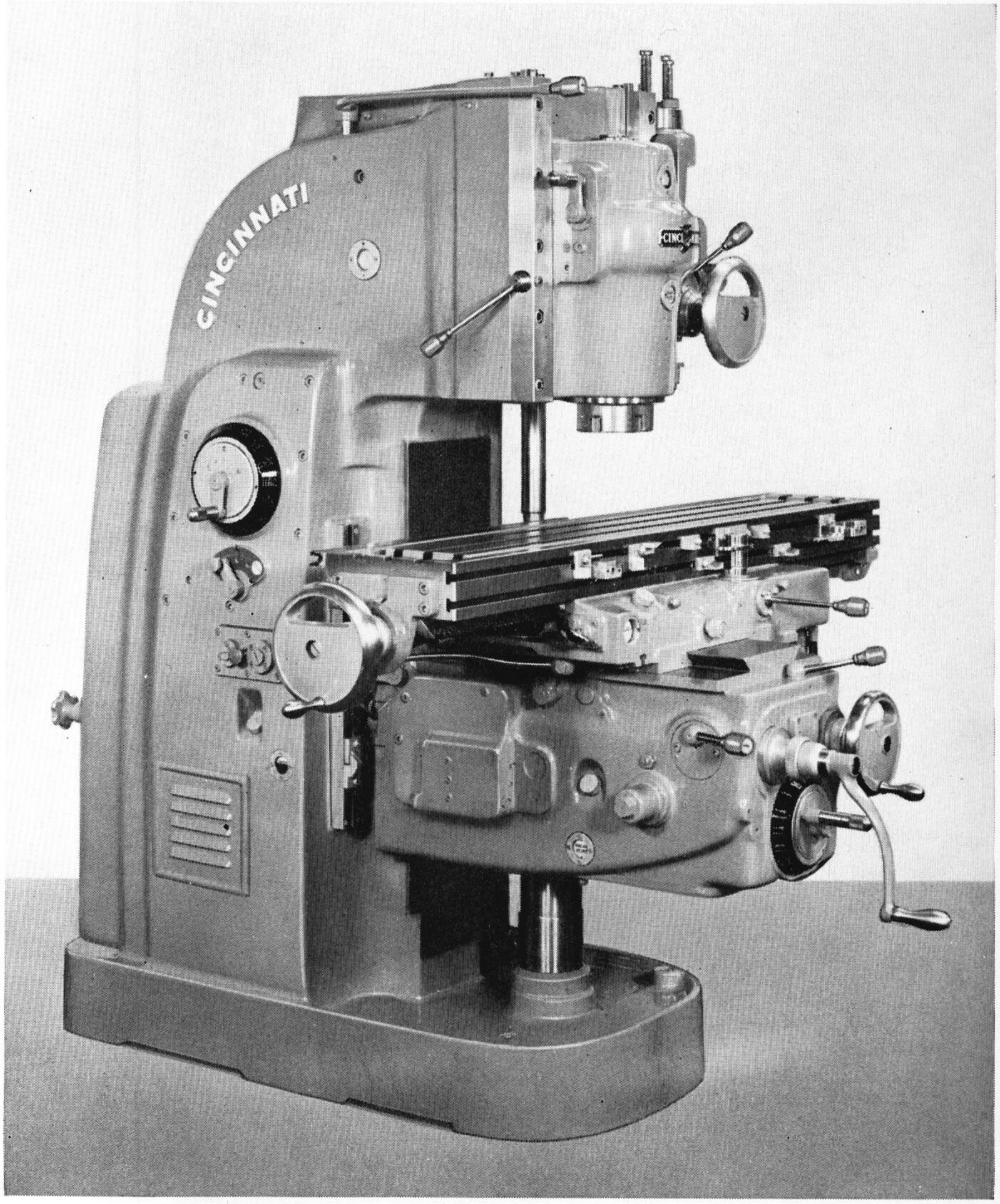
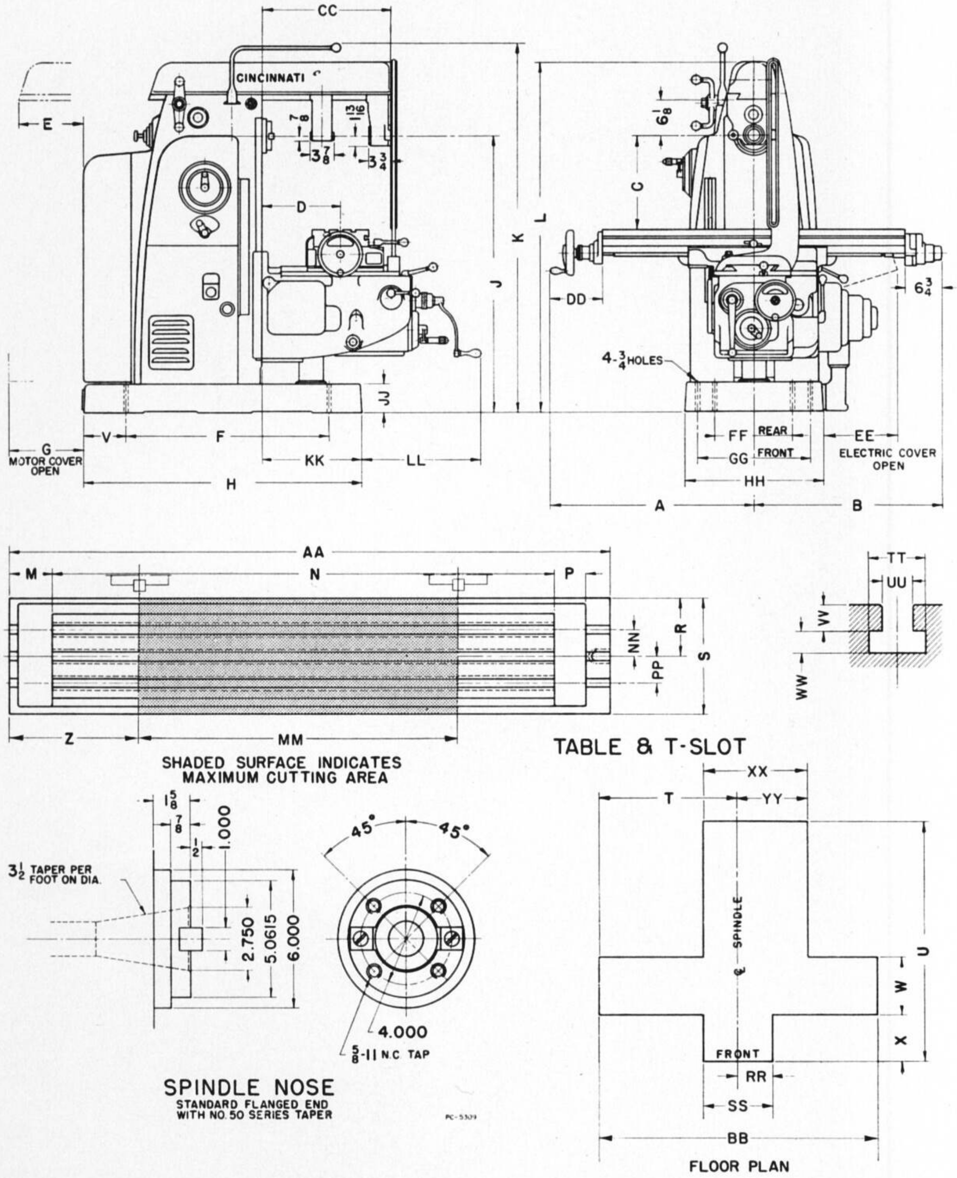


Figure 7A
CINCINNATI No. 205-10 MI Vertical Milling Machine
(Automatic Table Cycle available at extra cost)

DIMENSIONAL DRAWINGS



SIZE	A		B		C		D			E	F	G	H	J	K	L	M	N	P	R	S	T	U	V	W	X	Z
	MAX.	MIN.	MAX.	MIN.	MAX.	MIN.	W/OUT BRACE	WITH BRACE	MIN.																		
PLAIN 203-10 ML	49 1/16	21 1/16	49 7/16	21 7/16	16½	0	17 9/16	13⅝	7 9/16	16½	33¾	16¼	43⅞	46¼	62⅝	59⅜	3¾	45 9/16	2¾	4 11/16	10	49 5/16	81 3/16	4⅜	19 11/16	16 3/16	11¾
UNIV.	50 9/16	22 9/16	47 15/16	19 15/16	16	0	17 9/16	13⅝	7 9/16	16½	33¾	16¼	43⅞	46¼	62⅝	59⅜	3¾	45 9/16	2¾	4 11/16	10	50 13/16	81 3/16	4⅜	19½	16 3/16	13¼

SIZE	AA	BB	CC		DD	EE	FF	GG	HH	JJ	KK	LL	MM	NN	PP	RR	SS	TT	UU	VV	WW	XX	YY
			WITH BRACE	W/OUT BRACE																			
PLAIN 203-10 ML	54 7/16	99	22 11/16	25	9 5/16	14½	13½	19½	24	5⅛	17½	21 1/16	28	2 5/16	2 5/16	11	22	1¼	11/16	¾	31/64	38½	26½
UNIV.	54 7/16	98¾	22 11/16	25	9 5/16	14½	13½	19½	24	5⅛	17½	21 1/16	28	2 5/16	2 5/16	11	22	1¼	11/16	¾	31/64	38½	26½

Figure 8A

Dimensional Drawing—No. 203-10 ML Plain and Universal Machines

GENERAL SPECIFICATIONS

	203-10 ML UNIV.	203-10 ML PLAIN
Table		
Working surface	$54\frac{7}{16}''$ x 10″	$54\frac{7}{16}''$ x 10″
Size over-all	$54\frac{7}{16}''$ x 10″	$54\frac{7}{16}''$ x 10″
T-slots, number and size	Three—$\frac{11}{16}''$	Three—$\frac{11}{16}''$
Distance between T-slots	$2\frac{5}{16}''$	$2\frac{5}{16}''$
Swivels	46° R and L	....
Range		
Longitudinal	28″	28″
Cross	10″	10″
Vertical	16″	$16\frac{1}{2}''$
Centerline spindle to top of table Max.	16″	$16\frac{1}{2}''$
Centerline spindle to top of table Min.	0	0
Spindle		
Spindle nose	No. 50 Std.	No. 50 Std.
Hole for draw-in bolt	$1\frac{1}{8}''$	$1\frac{1}{8}''$
Speeds Number	16	16
Speeds Range	25-1500 rpm	25-1500 rpm
25, 33, 43, 56, 76, 100, 130, 168, 225, 295, 385, 500, 680, 895, 1160, 1500 rpm.		
Low range of spindle speeds, 20 to 1200 rpm, or high range of spindle speeds, 33 to 2000 rpm, may be obtained at the time the order is placed.		
Feed		
Number of feeds	16	16
Range Longitudinal and cross	$\frac{1}{4}$-30″/min.	$\frac{1}{4}$-30″/min.
Range Vertical	$\frac{1}{8}$-15″/min.	$\frac{1}{8}$-15″/min.
$\frac{1}{4}$, $\frac{5}{16}$, $\frac{7}{16}$, $\frac{5}{8}$, $\frac{7}{8}$, $1\frac{1}{4}$, $1\frac{3}{4}$, $2\frac{3}{8}$, $3\frac{1}{4}$, $4\frac{1}{2}$, $6\frac{1}{8}$, $8\frac{3}{8}$, $11\frac{1}{2}$, 16, 22, 30″ per min. Vertical rates are $\frac{1}{2}$ the foregoing. An optional feed range of $\frac{1}{2}''$ to 60″ per minute can be supplied at the time the order is placed. Longitudinal, cross, and vertical feed rates are then in the same proportion as standard.		
Power Rapid Traverse (Spindle Running or Stopped)		
Longitudinal and Cross	150″/min.	150″/min.
Vertical	75″/min.	75″/min.
Dividing Head		
Size (nominal swing)	10″	....
Max. length of work between centers	$28\frac{7}{8}''$	....
Overarm (Dynapoise)		
Underside to centerline of spindle	$6\frac{1}{8}''$	$6\frac{1}{8}''$
Drive		
Spindle drive motor	3 hp	3 hp
Feed drive motor	$1\frac{1}{2}$ hp	$1\frac{1}{2}$ hp
Floor Space		
Maximum size	$98\frac{3}{4}''$ x $81\frac{3}{16}''$	99″ x $81\frac{3}{16}''$
Area	56 sq. ft.	56 sq. ft.
Shipping Data (Approx.)		
Net weight	3850 lbs.	3650 lbs.
Gross weight, domestic	4450 lbs.	4250 lbs.
Gross weight, export	4750 lbs.	4550 lbs.
Shipping case Size (length x height x width)	72″ x 68″ x 42″	72″ x 68″ x 42″
Shipping case Volume	119 cu. ft.	119 cu. ft.
Code Names		
Conventional Table Feed Machines	YUWHE	YUWHA
Automatic Table Feed Machines	....	YUWHJ

Note.—General specifications for Plain Machines with and without Automatic Table Cycles. Automatic Table Cycles not available on Universal Machines.

DIMENSIONAL DRAWINGS

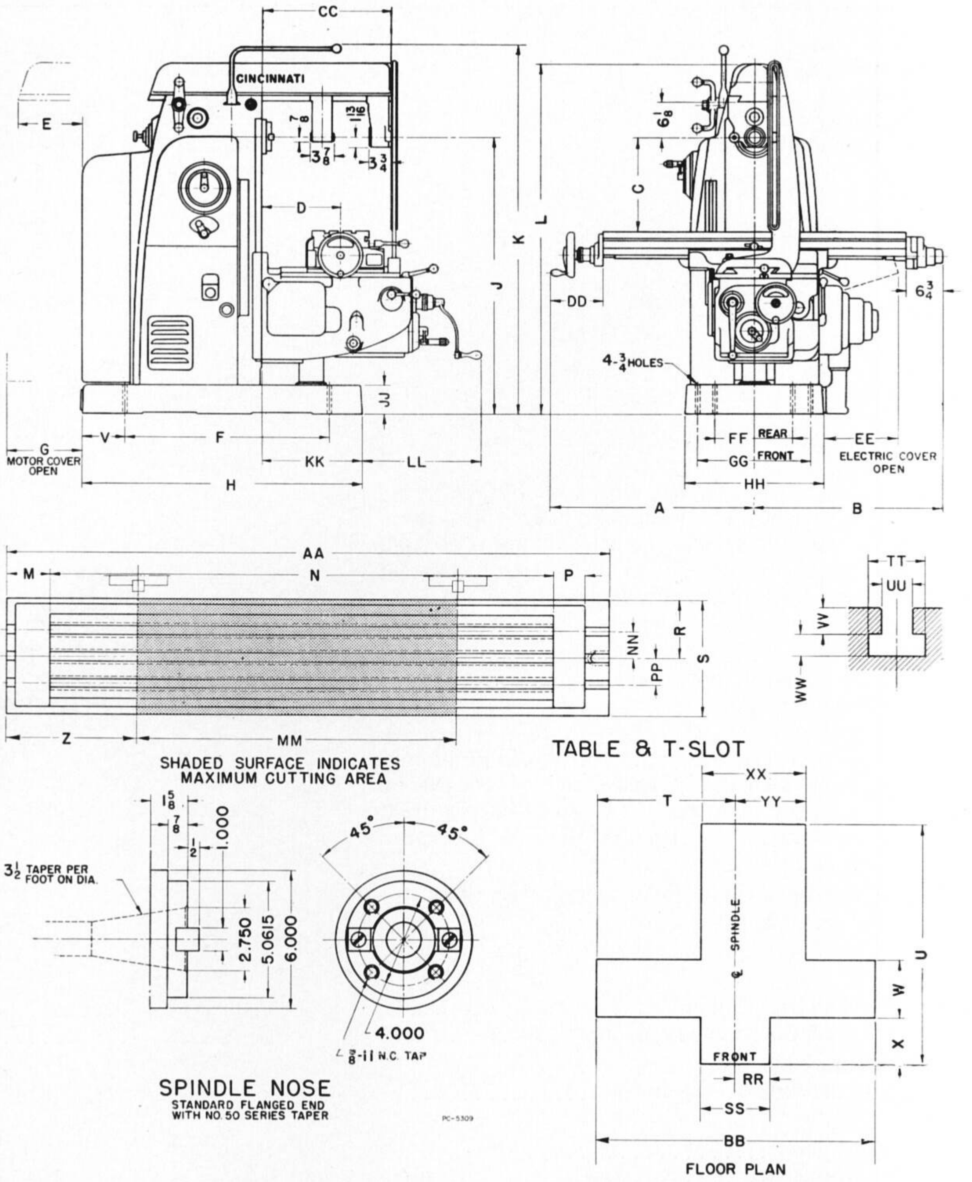


TABLE & T-SLOT

SPINDLE NOSE

STANDARD FLANGED END
WITH NO. 50 SERIES TAPER

FLOOR PLAN

SIZE	A		B		C		D			E	F	G	H	J	K	L	M	N	P	R	S	T	U	V	W	X	Z
	MAX.	MIN.	MAX.	MIN.	MAX.	MIN.	W/OUT BRACE	WITH BRACE	MIN.																		
PLAIN 205-10 MI	49 1/16	21 1/16	49 7/16	21 7/16	18 1/2	0	17 9/16	13 5/8	7 9/16	12 1/2	35 3/4	14 1/4	47 7/8	48 1/4	64 5/8	61 3/8	3 3/4	45 9/16	2 3/4	5	10	49 5/16	83 3/16	6 3/8	20	16 3/16	11 3/4
UNIV.	50 9/16	22 9/16	47 15/16	19 15/16	18	0	17 9/16	13 5/8	7 9/16	12 1/2	35 3/4	14 1/4	47 7/8	48 1/4	64 5/8	61 3/8	3 3/4	45 9/16	2 3/4	5	10	50 13/16	83 3/16	6 3/8	20	16 3/16	13 1/4

SIZE	AA	BB	CC		DD	EE	FF	GG	HH	JJ	KK	LL	MM	NN	PP	RR	SS	TT	UU	VV	WW	XX	YY
			WITH BRACE	W/OUT BRACE																			
PLAIN 205-10 MI	54 7/16	99	22 11/16	25	9 5/16	14 1/2	13 1/2	19 1/2	24	5 1/8	17 1/2	21 1/16	28	2 5/16	2 5/16	11	22	1 1/4	11/16	3/4	31/64	38 1/2	26 1/2
UNIV.	54 7/16	98 3/4	22 11/16	25	9 5/16	14 1/2	13 1/2	19 1/2	24	5 1/8	17 1/2	21 1/16	28	2 5/16	2 5/16	11	22	1 1/4	11/16	3/4	31/64	38 1/2	26 1/2

Figure 10A
Dimensional Drawing—No. 205-10 MI Plain and Universal Machines

GENERAL SPECIFICATIONS

	205-10 MI UNIV.	205-10 MI PLAIN
Table		
Working surface	54 7/16″ x 10″	54 7/16″ x 10″
Size over-all	54 7/16″ x 10″	54 7/16″ x 10″
T-slots, number and size	Three—11/16″	Three—11/16″
Distance between T-slots	2 5/16″	2 5/16″
Swivels	46° R and L	....
Range		
Longitudinal	28″	28″
Cross	10″	10″
Vertical	18″	18½″
Centerline spindle to top of table: Max.	18″	18½″
Centerline spindle to top of table: Min.	0	0
Spindle		
Spindle nose	No. 50 Std.	No. 50 Std.
Hole for draw-in bolt	1⅛″	1⅛″
Speeds: Number	16	16
Speeds: Range	25-1500 rpm	25-1500 rpm
25, 33, 43, 56, 76, 100, 130, 168, 225, 295, 385, 500, 680, 895, 1160, 1500 rpm.		
Low range of spindle speeds, 20 to 1200 rpm, or high range of spindle speeds, 33 to 2000 rpm, may be obtained at the time the order is placed.		
Feed		
Number of feeds	16	16
Range: Longitudinal and cross	¼-30″/min.	¼-30″/min.
Range: Vertical	⅛-15″/min.	⅛-15″/min.
¼, 5/16, 7/16, ⅝, ⅞, 1¼, 1¾, 2⅜, 3¼, 4½, 6⅛, 8⅜, 11½, 16, 22, 30″ per min. Vertical rates are ½ the foregoing. An optional feed range of ½″ to 60″ per minute can be supplied at the time the order is placed. Longitudinal, cross, and vertical feed rates are then in the same proportion as standard.		
Power Rapid Traverse (Spindle Running or Stopped)		
Longitudinal and Cross	150″/min.	150″/min.
Vertical	75″/min.	75″/min.
Dividing Head		
Size (nominal swing)	10″	....
Max. length of work between centers	28⅞″	....
Overarm (Dynapoise)		
Underside to centerline of spindle	6⅛″	6⅛″
Drive		
Spindle drive motor	5 hp	5 hp
Feed drive motor	1½ hp	1½ hp
Floor Space		
Maximum size	98¾″ x 83 3/16″	99″ x 83 3/16″
Area	57 sq. ft.	58 sq. ft.
Shipping Data (Approx.)		
Net weight	4900 lbs.	4650 lbs.
Gross weight, domestic	5600 lbs.	5300 lbs.
Gross weight, export	5900 lbs.	5600 lbs.
Shipping case: Size (length x height x width)	72″ x 70″ x 42″	72″ x 70″ x 42″
Shipping case: Volume	123 cu. ft.	123 cu. ft.
Code Names		
Conventional Table Feed Machines	YUWHF	YUWHB
Automatic Table Feed Machines	....	YUWHK

Note.—General specifications for Plain Machines with and without Automatic Table Cycles. Automatic Table Cycles not available on Universal Machines.

DIMENSIONAL DRAWINGS

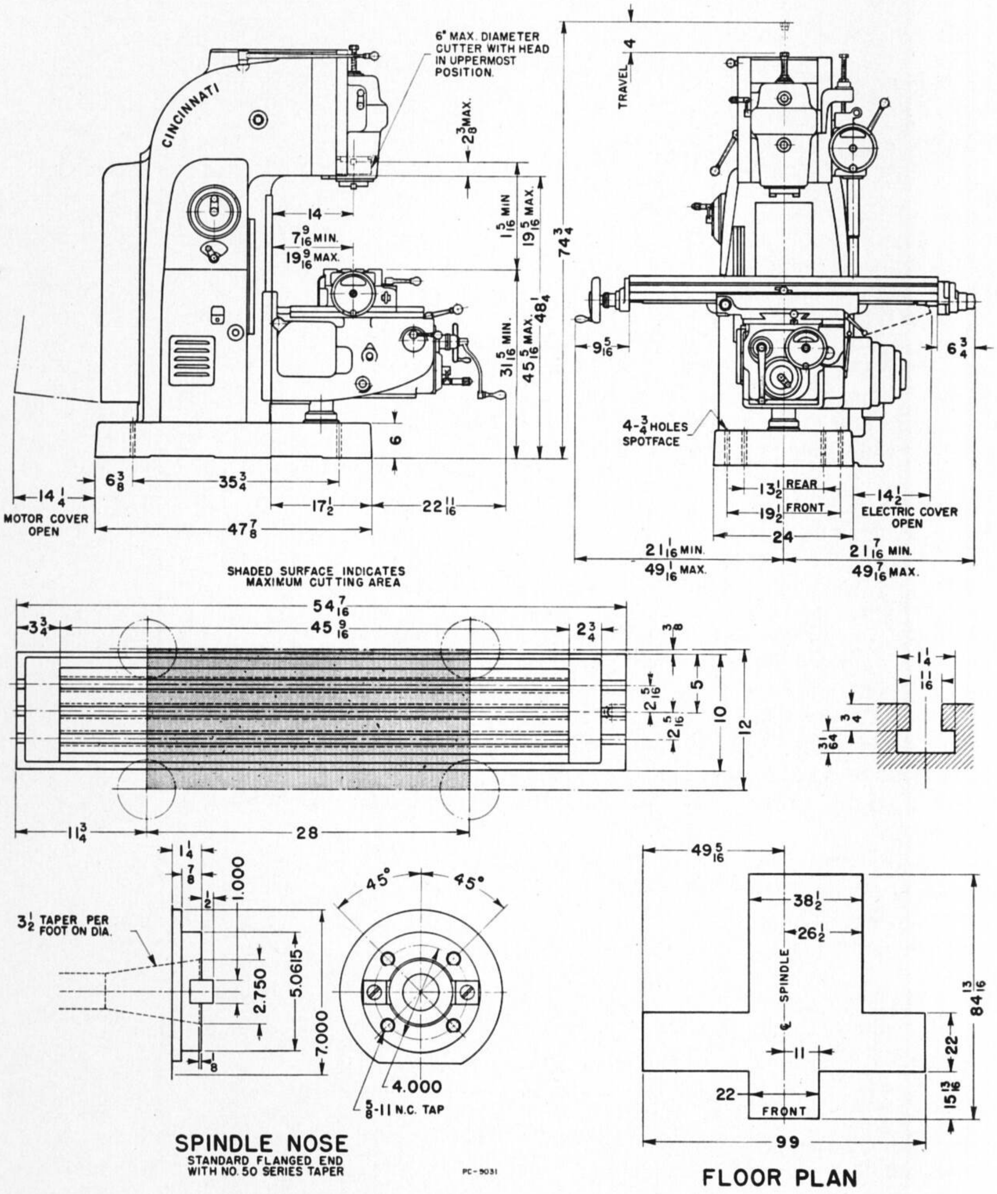


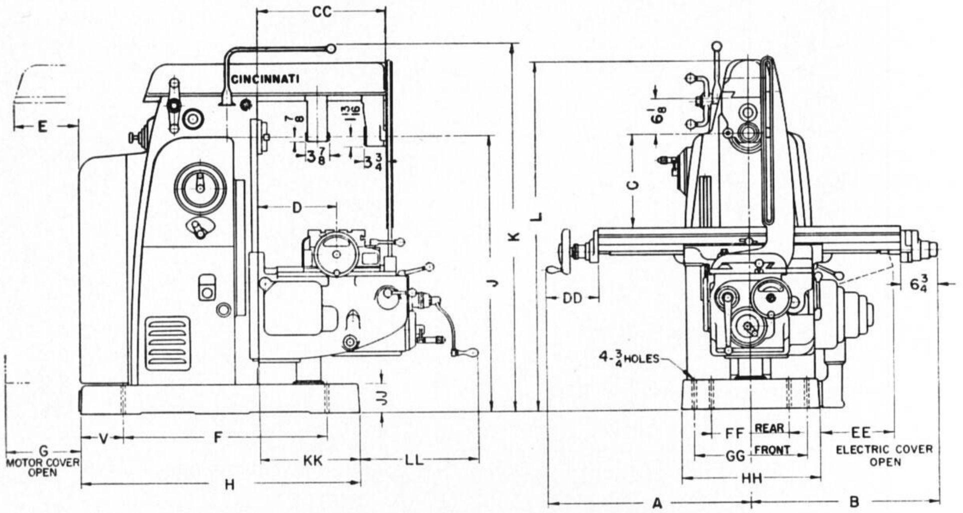
Figure 12A
Dimensional Drawing No. 205-10 MI Vertical Machines

GENERAL SPECIFICATIONS

	205-10 MI VERTICAL
Table	
Working surface	54$\frac{7}{16}$″ x 10″
Size over-all	54$\frac{7}{16}$″ x 10″
T-slots, number and size	Three—$\frac{11}{16}$″
Distance between T-slots	2$\frac{5}{16}$″
Range	
Longitudinal	28″
Cross	12″
Vertical — Knee travel	14″
Vertical — Head travel	4″
Spindle nose to top of table — Max.	19$\frac{5}{16}$″
Spindle nose to top of table — Min.	1$\frac{5}{16}$″
Spindle	
Spindle nose	No. 50 Std.
Hole for draw-in bolt	1$\frac{1}{8}$″
Speeds — Number	16
Speeds — Range	25-1500 rpm
25, 33, 43, 56, 76, 100, 130, 168, 225, 295, 385, 500, 680, 895, 1160, 1500 rpm.	
Low range of spindle speeds, 20 to 1200 rpm, or high range of spindle speeds, 33 to 2000 rpm, may be obtained at the time the order is placed.	
Feed	
Number of feeds	16
Range — Longitudinal and cross	$\frac{1}{4}$-30″/min.
Range — Vertical	$\frac{1}{8}$-15″/min.
$\frac{1}{4}$, $\frac{5}{16}$, $\frac{7}{16}$, $\frac{5}{8}$, $\frac{7}{8}$, 1$\frac{1}{4}$, 1$\frac{3}{4}$, 2$\frac{3}{8}$, 3$\frac{1}{4}$, 4$\frac{1}{2}$, 6$\frac{1}{8}$, 8$\frac{3}{8}$, 11$\frac{1}{2}$, 16, 22, 30″ per min. Vertical rates are $\frac{1}{2}$ the foregoing.	
An optional feed range of $\frac{1}{2}$″ to 60″ per minute can be supplied at the time the order is placed. Longitudinal, cross, and vertical feed rates are then in the same proportion as standard.	
Power Rapid Traverse (Spindle Running or Stopped)	
Longitudinal and cross	150″/min.
Vertical	75″/min.
Vertical Head	
Number of feeds	16
Feed range and rates	$\frac{1}{2}$ longitudinal feeds
Rapid traverse	75″ per min.
Drive	
Spindle drive motor	5 hp
Feed drive motor	1$\frac{1}{2}$ hp
Floor Space	
Maximum size	99″ x 84$\frac{13}{16}$″
Area	58 sq. ft.
Shipping Data	
Net weight	5150 lbs.
Gross weight, domestic	5850 lbs.
Gross weight, export	6200 lbs.
Shipping case — Size (length x height x width)	72″ x 80″ x 42″
Shipping case — Volume	140 cu. ft
Code Names	
Conventional table feed machines	YUWHI
Automatic table feed machines	YUWHN

Note.—General Specifications for Machines with and without Automatic Table Cycle.

DIMENSIONAL DRAWINGS



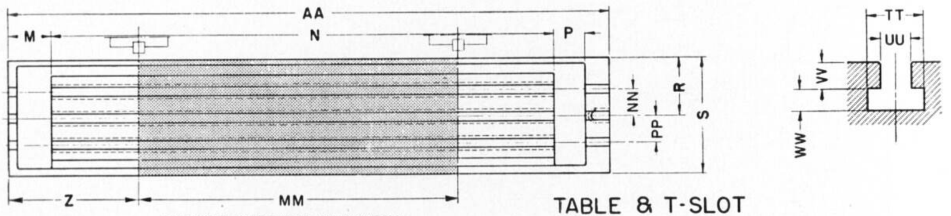
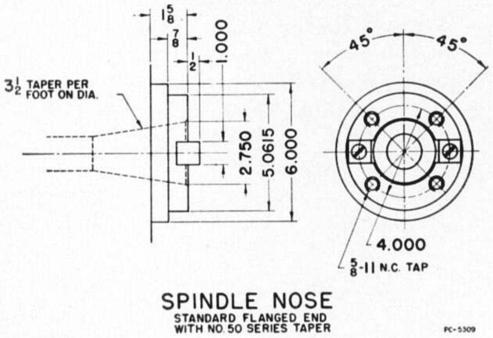
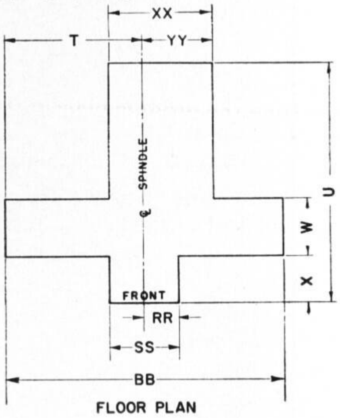


TABLE & T-SLOT

SHADED SURFACE INDICATES MAXIMUM CUTTING AREA



SPINDLE NOSE
STANDARD FLANGED END
WITH NO. 50 SERIES TAPER



FLOOR PLAN

SIZE	A		B		C		D			E	F	G	H	J	K	L	M	N	P	R	S	T	U	V	W	X	Z
	MAX.	MIN.	MAX.	MIN.	MAX.	MIN.	W/OUT BRACE	WITH BRACE	MIN.																		
PLAIN 307-14 MI UNIV.	57 1/16	23 1/16	58⅛	24⅛	20	0	21⅞	20	9⅞	19⅛	43½	17½	56½	51½	70¾	65⅞	3¾	54	2¾	7	14	57 5/16	100 5/16	6⅝	26	18 1/16	11⅛
	58 3/16	24 3/16	57	23	19	0	21⅞	21	9⅞	19⅛	43½	17½	56½	51½	70¾	65⅞	3¾	54	2¾	7	14	58 7/16	100 5/16	6⅝	26	18 1/16	12 3/1
PLAIN 410-14 MI UNIV.	65 1/16	23 1/16	66⅛	24⅛	20	0	21⅞	20	9⅞	19⅛	43½	17½	56½	51½	70¾	65⅞	3 9/16	68⅜	2 9/16	7	14	65 1/16	100 5/16	6⅝	26	18 1/16	11⅛
	66 3/16	24 3/16	65	23	19	0	21⅞	21	9⅞	19⅛	43½	17½	56½	51½	70¾	65⅞	3 9/16	68⅜	2 9/16	7	14	66 3/16	100 5/16	6⅝	26	18 1/16	12¼

SIZE	AA	BB	CC		DD	EE	FF	GG	HH	JJ	KK	LL	MM	NN	PP	RR	SS	TT	UU	VV	WW	XX	YY
			WITH BRACE	W/OUT BRACE																			
PLAIN 307-14 MI UNIV.	62½	115 5/16	30 13/16	32⅜	11 15/16	18¼	16	24	28½	5	22	24 11/16	34	3¼	3¼	13	24	1 15/32	13/16	⅞	⅝	51	31
	62½	115 5/16	30 13/16	32⅜	11 15/16	18¼	16	24	28½	5	22	24 11/16	34	3¼	3¼	13	24	1 15/32	13/16	⅞	⅝	51	31
PLAIN 410-14 MI UNIV.	70½	131 3/16	30 13/16	32⅜	11 15/16	18¼	16	24	28½	5	22	24 11/16	42	3¼	3¼	13	24	1 15/32	13/16	⅞	⅝	51	33
	70½	131 3/16	30 13/16	32⅜	11 15/16	18¼	16	24	28½	5	22	24 11/16	42	3¼	3¼	13	24	1 15/32	13/16	⅞	⅝	51	33

Figure 14A

Dimensional Drawing—Nos. 307-14 and 410-14 MI Plain and Universal Machines

GENERAL SPECIFICATIONS

	307-14 MI		410-14 MI	
	UNIV.	**PLAIN**	**UNIV.**	**PLAIN**
Table				
Working surface	62½″ x 14″		70½″ x 14″	
Size over-all	62½″ x 14″		70½″ x 14″	
T-slots, number and size	Three—13/16″		Three—13/16″	
Distance between T-slots	3¼″		3¼″	
Swivels	46° R & L	....	46° R & L	....
Range				
Longitudinal	34″		42″	
Cross	12″		12″	
Vertical	19″	20″	19″	20″
Centerline spindle to top of table — Max.	19″	20″	19″	20″
Centerline spindle to top of table — Min.	0″	0″	0″	0″
Spindle				
Spindle nose	No. 50 Std.		No. 50 Std.	
Hole for draw-in bolt	1⅛″		1⅛″	
Speeds — Number	16		16	
Speeds — Range	25—1500 rpm		33—2000 rpm	
25, 33, 43, 56, 76, 100, 130, 168, 225, 295, 385, 500, 680, 895, 1160, 1500 rpm.				
Low range of spindle speeds, 20 to 1200 rpm, or high range of spindle speeds, 33 to 2000 rpm, may be obtained at the time the order is placed.				
Feed				
Number of feeds	16		16	
Range — Longitudinal and cross	¼-30″/min.		¼-30″/min.	
Range — Vertical	⅛-15″/min.		⅛-15″/min.	
¼, 5/16, 7/16, ⅝, ⅞, 1¼, 1¾, 2⅜, 3¼, 4½, 6⅛, 8⅜, 11½, 16, 22, 30″ per min. Vertical rates are ½ the foregoing. An optional feed range of ½″ to 60″ per minute can be supplied at the time the order is placed. Longitudinal, cross, and vertical feed rates are then in the same proportion as standard.				
Power Rapid Traverse (Spindle Running or Stopped)				
Longitudinal and Cross	150″/min.		150″/min.	
Vertical	75″/min.		75″/min.	
Dividing Head				
Size (nominal swing)	12″	....	14″	....
Max. length of work between centers	36½″	....	44½″	....
Overarm (Dynapoise)				
Underside to centerline of spindle	6⅛″		6⅛″	
Drive				
Spindle drive motor	7½ or 10*hp		10 hp	
Feed drive motor	3 hp		3 hp	
Floor Space				
Maximum size	115 5/16″ x 100 5/16″		131 3/16″ x 100 5/16″	
Area	80 sq. ft.		90 sq. ft.	
Shipping Data (Approx. Lbs.)				
Net weight	6950	6500	7075	6675
Gross weight, domestic	7950	7500	8075	7675
Gross weight, export	8150	7700	8275	7875
Shipping case — Size (length x height x width)	90″ x 73″ x 50″		90″ x 73″ x 50″	
Shipping case — Volume	190 cu. ft.		190 cu. ft.	
Code Names				
Conventional Table Feed Machines	YUWHG	YUWHC	YUWHH	YUWHD
Automatic Table Feed Machines	....	YUWHL	....	YUWHM

Note.—General Specifications for Machines with or without Automatic Table Cycle. Not available on Universal Machines.
*10 hp., 33 to 2000 rpm (extra cost).

STANDARD EQUIPMENT SUPPLIED WITH THE MACHINE

PLAIN Nos. (203-10 ML and 205-10 MI)

Complete Electrical Equipment for 50 or 60 cycle, 2 or 3 phase, 220 to 550 volts A.C. and wired in accordance with the "Machine Tool Electrical Standards."

Spindle Drive Motor: Open, normal torque, normal starting current, N.E.M.A. frame, ball bearing. No. 205–10 MI, 5 hp. No. 203–10 ML, 3 hp.

Feed Drive Motor: Flange type 1½ hp.

Control: Full voltage magnetic starter with overload and undervoltage protection including transformer and push buttons operated at 110 volts.

Disconnect Switch: A non-fusible type is supplied.

Two Arbor Supports:

One Outer Style "B" with 2⅛" adjustable arbor bushing provided with lugs for brace.

One Style "A" with adjustable arbor bushing for pilot end arbors.

Automatic Backlash Eliminator.

Cutting Fluid Pump, motor driven.

Arbor-Loc Spindle Nose.

Adjustable Arbor Tightening Rod.

Wrenches. Overarm Brace.

Standard Feed Range, ¼" to 30" per min.

Rear Power Feed Control—longitudinal only.

Table Control Dogs: Machines without Automatic Table Cycles, two feed trip.

Machines with Automatic Table Cycles, two feed, two rapid traverse, two reverse, one end stop, one center safety stop.

UNIVERSAL (Nos. 203-10 ML and 205-10 MI)

Complete Electrical Equipment for 50 or 60 cycle, 2 or 3 phase, 220 to 550 volts A.C. and wired in accordance with the "Machine Tool Electrical Standards."

Spindle Drive Motor: Open, normal torque, normal starting current, N.E.M.A. frame, ball bearing. No. 205–10 MI, 5 hp. No. 203–10 ML, 3 hp.

Feed Drive Motor: Flange type 1½ hp.

Control: Full voltage magnetic starter with overload and undervoltage protection including transformer and push buttons operated at 110 volts.

Disconnect Switch: A non-fusible type is supplied.

Standard 10" Universal Dividing Head with No. 50 standard taper hole. Includes tailstock with 2-point adjustable center; steady rest; one plate for indexing through 40 to 1 reduction—all numbers up to and including 60, all even numbers and those divisible by 5 up to 120, and many beyond; direct indexing from spindle nose; one center for headstock; and provision for connecting head to enclosed driving mechanism segment.

Enclosed Driving Mechanism Segment, including change gears for spiral milling, leads range from 2½" to 100" (only) for Standard Universal Dividing Heads.

Automatic Backlash Eliminator.
Two Arbor Supports:
  One Outer Style "B" with 2⅛″ adjustable arbor bushing and provided with lugs for brace.
  One Style "A" with adjustable arbor bushing for pilot end arbors.
Cutting Fluid Pump, motor driven.
Arbor-Loc Spindle Nose.
Adjustable Arbor Tightening Rod.
Wrenches. Overarm brace.
Standard Feed Range, ¼″ to 30″ per min.
Rear Power Feed Control—longitudinal only.

VERTICAL (No. 205-10 MI)

Complete Electrical Equipment for 50 or 60 cycle, 2 or 3 phase, 220 to 550 volts A.C. and wired in accordance with the "Machine Tool Electrical Standards."
Spindle Drive Motor: Open, normal torque, normal starting current, N.E.M.A. frame, ball-bearing, 5 hp.
Feed Drive Motor: Flange type 1½ hp.
Control: Full voltage magnetic starter with overload and undervoltage protection including transformer and push buttons operated at 110 volts.
Disconnect Switch. A non-fusible type is supplied.
Power Feed and Power Quick Traverse to the Vertical Head.
Turret Stop, four-position with dial indicator.
Automatic Backlash Eliminator.
Cutting Fluid Pump, motor driven.
Arbor-Loc Spindle Nose.
Adjustable Arbor Tightening Rod.
Wrenches.
Standard Feed Range, ¼″ to 30″ per min.
Rear Power Feed Control—longitudinal only.
Table Control Dogs: Machines without Automatic Table Cycle, two feed trip.
  Machines with Automatic Table Cycles, two feed, two rapid traverse, two reverse, one end stop, one center safety stop.

PLAIN (Nos. 307-14 and 410-14 MI)

Complete Electrical Equipment for 50 or 60 cycle, 2 or 3 phase, 220 to 550 volts A.C. and wired in accordance with the "Machine Tool Electrical Standards."
Spindle Drive Motor: Open, normal torque, normal starting current, N.E.M.A. frame, ball bearing, 7½ hp. for 307-14, 10 hp. for 410-14.
Feed Drive Motor: Flange type 3 hp.
Control: Full voltage magnetic starter with overload and undervoltage protection including transformer and push buttons operated at 110 volts.
Disconnect Switch: A non-fusible type is supplied.
Two Arbor Supports:
  One Outer Style "B" with 2⅛″ adjustable arbor bushing provided with lugs for brace.
  One Style "B" with 2⅛″ adjustable arbor bushing without lugs for brace.

Automatic Backlash Eliminator.
Cutting Fluid Pump, motor driven.
Arbor-Loc Spindle Nose.
Adjustable Arbor Tightening Rod.
Wrenches. Overarm Brace.
Standard Feed Range, ¼″ to 30″ per min.
Arbor Support Bushing Adapter M-O1 (includes adjustable bushing, nut, washer and screw) for Style "A" arbor.
Table Control Dogs: Machines without Automatic Table Cycles, two feed trip.
Machines with Automatic Table Cycles, two feed, two rapid traverse, two reverse, one end stop, one center safety stop.
Rear Hand Adjustments and Rear Power Feed Controls—longitudinal, cross and vertical.

UNIVERSAL (Nos. 307-14 and 410-14 MI)

Complete Electrical Equipment for 50 or 60 cycle, 2 or 3 phase, 220 to 550 volts A.C. and wired in accordance with the "Machine Tool Electrical Standards."
Spindle Drive Motor: Open, normal torque, normal starting current, N.E.M.A. frame, ball bearing, 7½ hp for 307–14, 10 hp for 410–14.
Feed Drive Motor: Flange type 3 hp.
Control: Full voltage magnetic starter with overload and undervoltage protection including transformer and push buttons operated at 110 volts.
Disconnect Switch: A non-fusible type is supplied.
Standard 12″ (307–14), 14″ (410–14) Universal Dividing Head with No. 50 standard taper hole. Includes tailstock with 2-point adjustable center; steady rest; one plate for indexing through 40 to 1 reduction—all numbers up to and including 60, all even numbers and those divisible by 5 up to 120, and many beyond; direct indexing from spindle nose; one center for headstock; and provision for connecting head to enclosed driving mechanism segment.
Enclosed Driving Mechanism Segment, including change gears for spiral milling, leads range from 2½″ to 100″ (only) for Standard Universal Dividing Heads.
Two Arbor Supports:
One Outer Style "B" with 2⅛″ adjustable arbor bushing and provided with lugs for brace.
One Style "B" with 2⅛″ adjustable arbor bushing without lugs for brace.
Arbor Support Bushing Adapter M-O1 (includes adjustable bushing, nut, washer and screw) for Style "A" arbor.
Cutting Fluid Pump, motor driven.
Arbor-Loc Spindle Nose.
Adjustable Arbor Tightening Rod.
Automatic Backlash Eliminator.
Wrenches. Overarm brace.
Standard Feed Range, ¼″ to 30″ per min.
Rear Hand Adjustments and Rear Power Feed Controls—longitudinal, cross and vertical.

INSTALLATION INSTRUCTIONS

To obtain accurate results from a milling machine over a long period of time, three external requirements must be met. First, the foundation upon which the machine sets must be heavy enough to maintain stability and flatness under the weight of the machine. Second, the machine must be firmly anchored in place to the foundation. Third, the machine must be carefully leveled and then checked occasionally to be sure that level is maintained.

Foundation. If the floor upon which the CINCINNATI ML or MI Milling Machine will be located is made of substantial wood or concrete, fairly flat, and sufficiently heavy enough to withstand the weight of the machine, no special foundation will be required. For floors of lesser stability and strength, a foundation should be built up equal to or better than this floor specification. (Check machine specifications for weights).

Lifting the Machine. The plain and universal machines may be lifted by a crane with a rope or cable sling around the overarm (Figure 19A). Tighten the overarm clamping bolts before lifting.

The vertical machines may be lifted by a crane with a rope or cable sling around the throat (Figure 19B). Before lifting, adjust the saddle to the front of the knee to balance the weight.

If wire cables are used to lift the machines, protect the machined surfaces with leather padding or wood blocks.

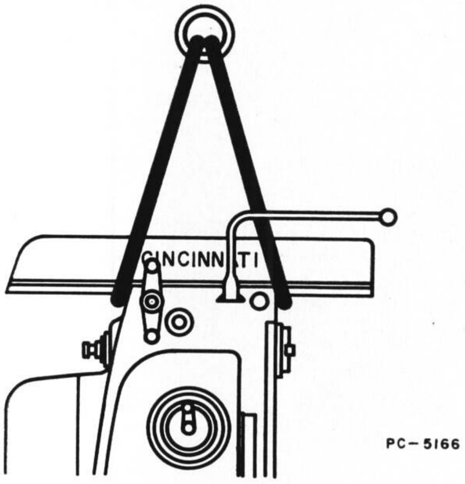


Figure 19A
Lifting the Plain and Universal Machines

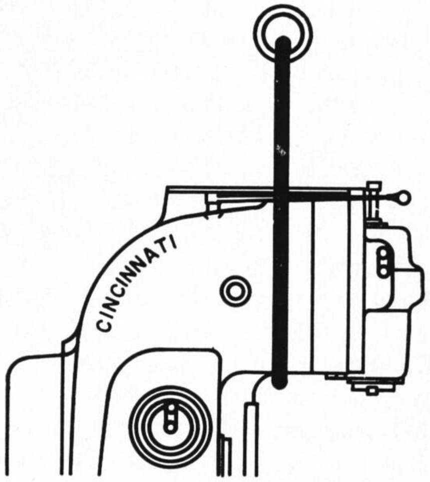


Figure 19B
Lifting the Vertical Machines

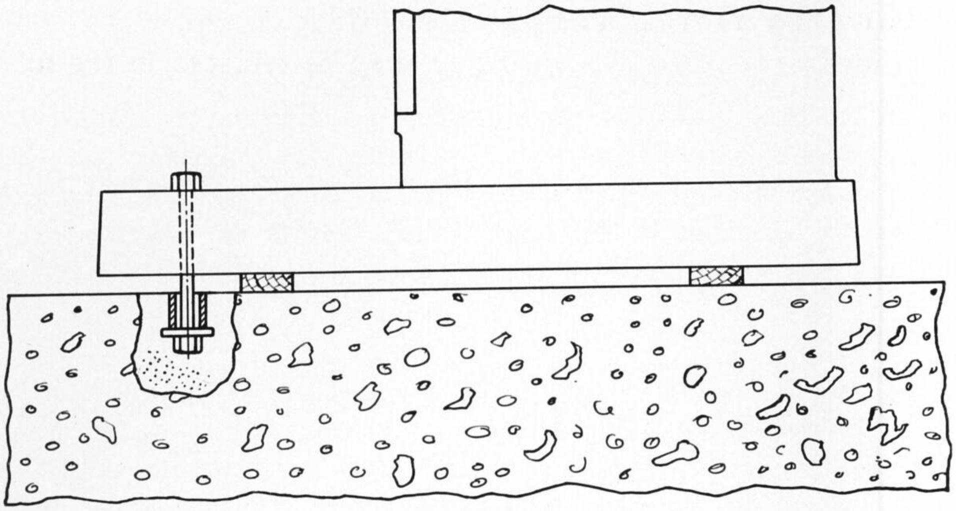


Figure 20A
Bolting the Machine to a Concrete Floor

Bolting the Machine to the Floor. When preparing for this operation, notice that center distances of bolt holes given on the "floor plans" are approximated. If the floor is concrete, drill the bolt holes about 6″ in diameter. Insert the hold-down bolt through a 1½″ pipe, as illustrated in Figure 20A, and fill the pipe with dry sand. Lower the machine on two 1″ thick boards, and engage the nuts on two or three threads of the bolts. Fill the holes around the pipe with quick drying cement, thin enough to flow easily. When cement is dry, remove boards, level machine, and tighten hold-down nuts.

Leveling. After the machine has been moved to its proper location, it must be carefully leveled. Use an accurate micrometer level for the operation. A carpenter's level or the bulb in a machinist's combination square is not good enough. Place laminated shims under the bearing pads of the base (Figure 20B), alternating metal and felt shims, until the table is level in both directions. Shims should be large enough so entire bearing pad, under the base, is resting on the shim, so as to evenly distribute the weight of the machine. It is necessary, of course, that the machine table and leveling instrument be absolutely clean and free of burrs to obtain the most accurate results.

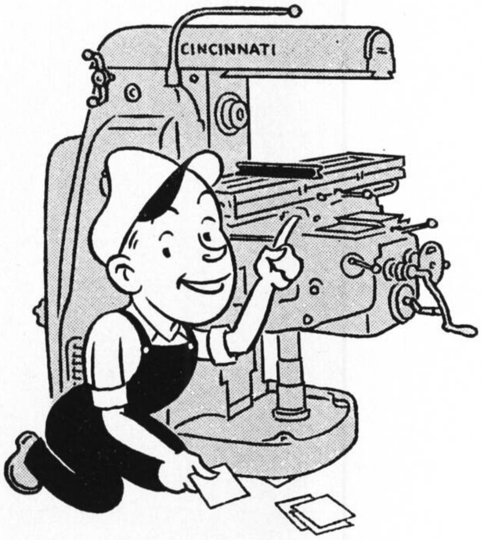


Figure 20B
Leveling the Machine

Assembling the Table to the Machine. If the machine table has been removed for convenience in shipping, it may be replaced in the following manner:

1. Wash the bearing surfaces on the saddle and table perfectly clean. Apply a liberal coat of oil to the saddle bearings.
2. Place the table feed engaging lever in its neutral position (clutch disengaged).
3. Insert the two table locking shoes and follow up with the table clamping screws (see Figure 39A).
4. Insert the table feed screw through the sleeves in the saddle, from the right hand side of the machine, and thread the screw through the nut in the left hand end of the saddle until the end of it projects about 15".
5. Slide the table into position, from left to right.
6. Insert the table gib in the left hand end of the saddle at the front.
7. Adjust the gib so that the table cannot be pulled by two men, then back off the gib screw until the table can be pulled. There must be no evidence of "side-play".
8. Connect the aprons to the ends of the table, the right end first and then the left end, pulling them up tightly. Be sure that the dowel pins are in place.
9. Assemble the clutch, dial, and handwheel at the left hand end.

Assembling the V-Belts to the Motor. Before assembling the V-belts to the motor, turn it over by hand a few times to be sure that it rotates freely, and that no objects have fallen into the motor during shipment or while it was being unpacked.

Counterweight (Vertical Machines). The sliding head of a vertical miller is balanced by a counterweight inside the machine column. The counterweight is held in position during shipment by two screws, one on each side of the column directly above the name CINCINNATI. Remove the screws and plug the holes with the plugs provided.

Backlash Eliminator. For convenience of shipping and/or installation, it is sometimes necessary to remove the table and lead screw. When this is done, the backlash eliminator must be properly reassembled and adjusted.

Reassembling Backlash Eliminator.

1. Remove wire. Remove one nut at a time for cleaning and replace in same position.
2. With nuts replaced, turn each until scribed line on nut matches scribed line on cap. Hold nuts firmly in position and run lead screw into both nuts. This holds correct radial position of threads relative to faces. With lead screw in position, be sure lines on caps and nuts are still in line.
3. Fit table to saddle and adjust bearings in apron for not more than .005″ backlash in lead screw dial.
4. Turn knob on front of saddle all the way in and try lead screw by hand. If backlash is evident, adjust as outlined on page 75-78.

   Note.—Table gib should be relatively loose when making test. Adjust gib to proper depth after checking eliminator.

LUBRICATION

After the machine has been installed in accordance with the information given in the "Installation Instructions" and the data sheet which accompany the machine, it must be thoroughly lubricated before being placed in operation.

Warning: Follow the instructions on the warning tag (Figure 23B) attached to the machine.

Do not start the machine until all stations have been filled with the proper amount of correct lubricants, as shown in the specifications, pages 24 and 25.

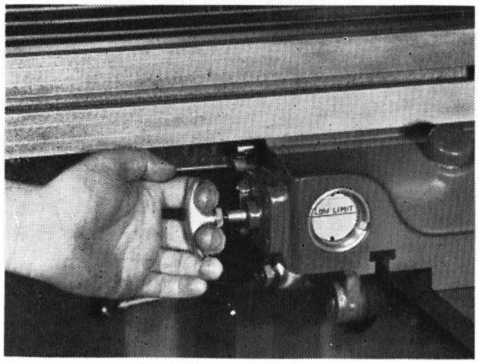
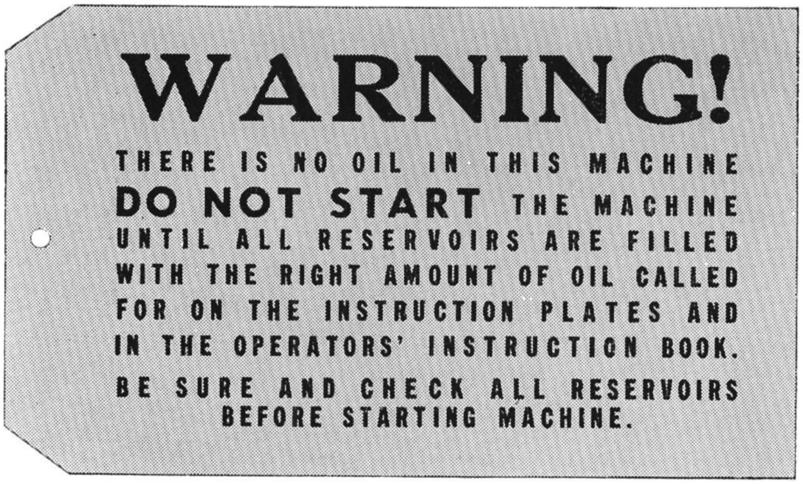


Figure 23A
Operating the Oil-Shot Plunger

When lubricating the machine, note in particular the saddle-table oil-shot lubrication system, Station 10 (Figure 24A). The oil level in this reservoir must be above the low limit at all times. If the oil is completely exhausted, air will get into the system, and it will be necessary to operate the plunger several times to be sure that all the air is eliminated. Pull the handle out to the full length of its stroke (Figure 23A) and allow it to ***return itself*** to its original position.



WARNING!

THERE IS NO OIL IN THIS MACHINE
DO NOT START THE MACHINE
UNTIL ALL RESERVOIRS ARE FILLED
WITH THE RIGHT AMOUNT OF OIL CALLED
FOR ON THE INSTRUCTION PLATES AND
IN THE OPERATORS' INSTRUCTION BOOK.
BE SURE AND CHECK ALL RESERVOIRS
BEFORE STARTING MACHINE.

Figure 23B
Warning Tag
Attached to
the Machine

The column oil strainer should be cleaned each time the oil in Station 12 is changed. After draining the oil from the column, remove the circular cover (Figure 24A) with a face spanner wrench. Pull out the strainer, wash in naphtha or some similar solvent, and then blow off the strainer with an air hose. Replace the strainer and cover.

If the machine is located in an exceptionally dusty atmosphere, as sometimes found near cutter sharpening machines, the table dovetail, knee-column bearing, and saddle-knee bearing should be wiped clean twice a day. After cleaning, apply oil to the bearing surfaces.

Important—To maintain cleanliness of oil in the hydraulic system, we recommend replacing the oil filter, Part No. 121486, every six months or more often if required. (Figure 27A)

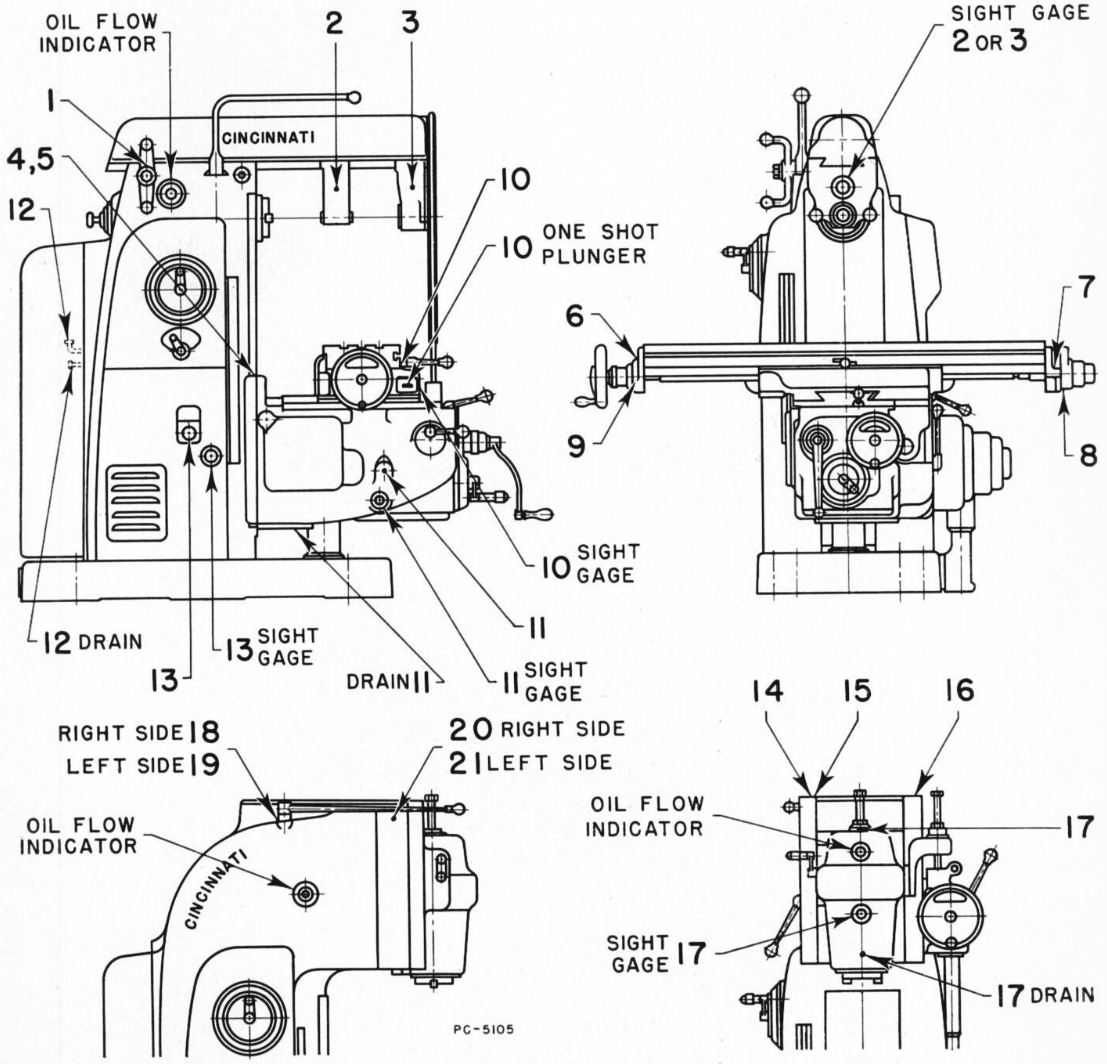


Figure 24A
Lubrication Diagram

LUBRICATING INSTRUCTIONS AND SPECIFICATIONS

See Lubrication Diagrams, opposite page

Thoroughly oil all moving parts as they are installed. Then lubricate all principal points as listed below before starting machine. Periodic and thorough lubrication with correct lubricant, as specified, will help maintain the long life and accuracy built into machine The intervals listed are based on a normal eight-hour day

PURCHASE LUBRICANTS FROM RELIABLE DEALERS !

When to Oil	Station Number	Instructions	Parts Lubication	Specifications
Daily	2 and 3	*Remove cap, keep filled to high limit. Use oil pot to fill. (Check daily).	Arbor support bearings.	P-55. Good quality paraffinic base rust and oxidation inhibited oil. Viscosity range 200-220 S.U.S @ 100° F
	4 and 5	Spring cap oil cups Keep filled. Use bench oiler to fill.	Knee-column vertical ways	
	6 and 7	Spring cap oil cups. Keep filled. Use bench oiler to fill.	Right and left end leadscrew bearings.	
	8 and 9	Spring cap oil cups Keep filled. Use bench oiler to fill. (Only when used).	Auxiliary drive shaft bushings.	
	14, 15 and 16	Spring cap oil cups. Keep filled. Use bench oiler to fill	Sliding ways in vertical head (Vertical machine only).	
	10	*Maintain oil level between high and low limit on gage. Twice daily, pull out plunger 3 times and allow to return by itself each time.	Table-saddle ways, knee-saddle ways under saddle bracket and cross feed screw internal gearing	
Weekly	1	Apply 2 or 3 drops Button oiler. Use bench oiler	Overarm pilot wheel bearings.	
Check Weekly	11	*Fill to high limit on gage Use oil pot to fill	Gears and bearings in knee	
	12	*Open main motor drive cover, fill to threads on pipe fitting. Use pot to fill	Gears and bearings in column.	
	17	*Fill to high limit on gage. Use oil pot to fill	Gears and bearings in vertical head.	
	13	*Fill to high limit on gage. Use oil pot to fill.	Vertical screw.	P-63. EP Lead Naphthenate type oil, viscosity range 300 to 360. S.U.S. @ 100°F.
Monthly	18, 19, 20 and 21	Apply 2 or 3 shots. Use hand grease gun.	Counterweight sprocket shaft bearings.	P-64. Lithium base grease NLGI No. 2 consistency.

*Quantities required: Stations Nos. 2 and 3 approx. 1½ qts., No. 10 approx. ⅓ qt., No. 11 approx. 1½ gals. No. 12 approx. 2½ gals., No. 13 approx. 1 qt., No. 17 approx. 1½ qts.

Note.—Lubricate motor according to motor manufacturer's specifications.

P-55, P-64 and P-63 are The Cincinnati Milling Machine Co. Specifications Numbers.

A list of approved products corresponding to the above specifications may be obtained from our Field Service Department.

STARTING THE MACHINE FOR THE FIRST TIME

After the machine has been properly installed and lubricated, and the slushing oil washed off, it is ready to start.

Momentarily start the motor and immediately notice the direction of rotation of the driving pulley at the rear of the machine. To start the motor with the motor compartment door open, the safety switch must be held in contact by hand while the regular starting button is pushed. (Figure 26B). The driving pulley must rotate clockwise as indicated by the direction plate (Figure 26A) attached to the pulley bracket directly above the driven pulley.

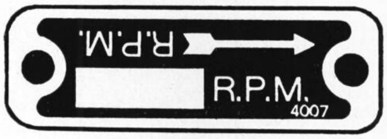


Figure 26A
Pulley Must Rotate in This Direction When Viewed From Rear of Machine

Run the machine for a half hour or so to insure a protective film of oil over all bearings, and apply oil frequently during this period. Do not fill the oil reservoirs while the machine is running.

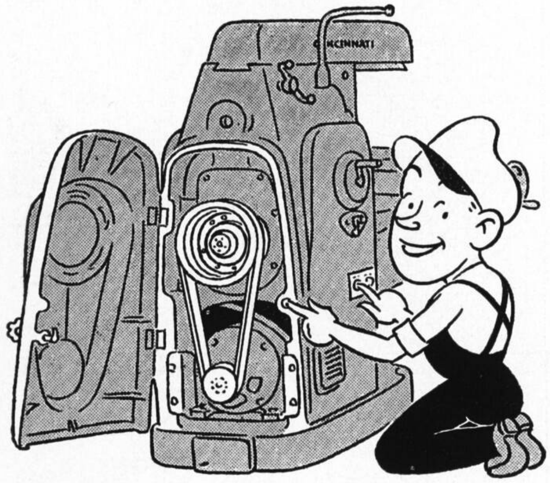


Figure 26B
Starting the Motor with the Motor Compartment Door Open

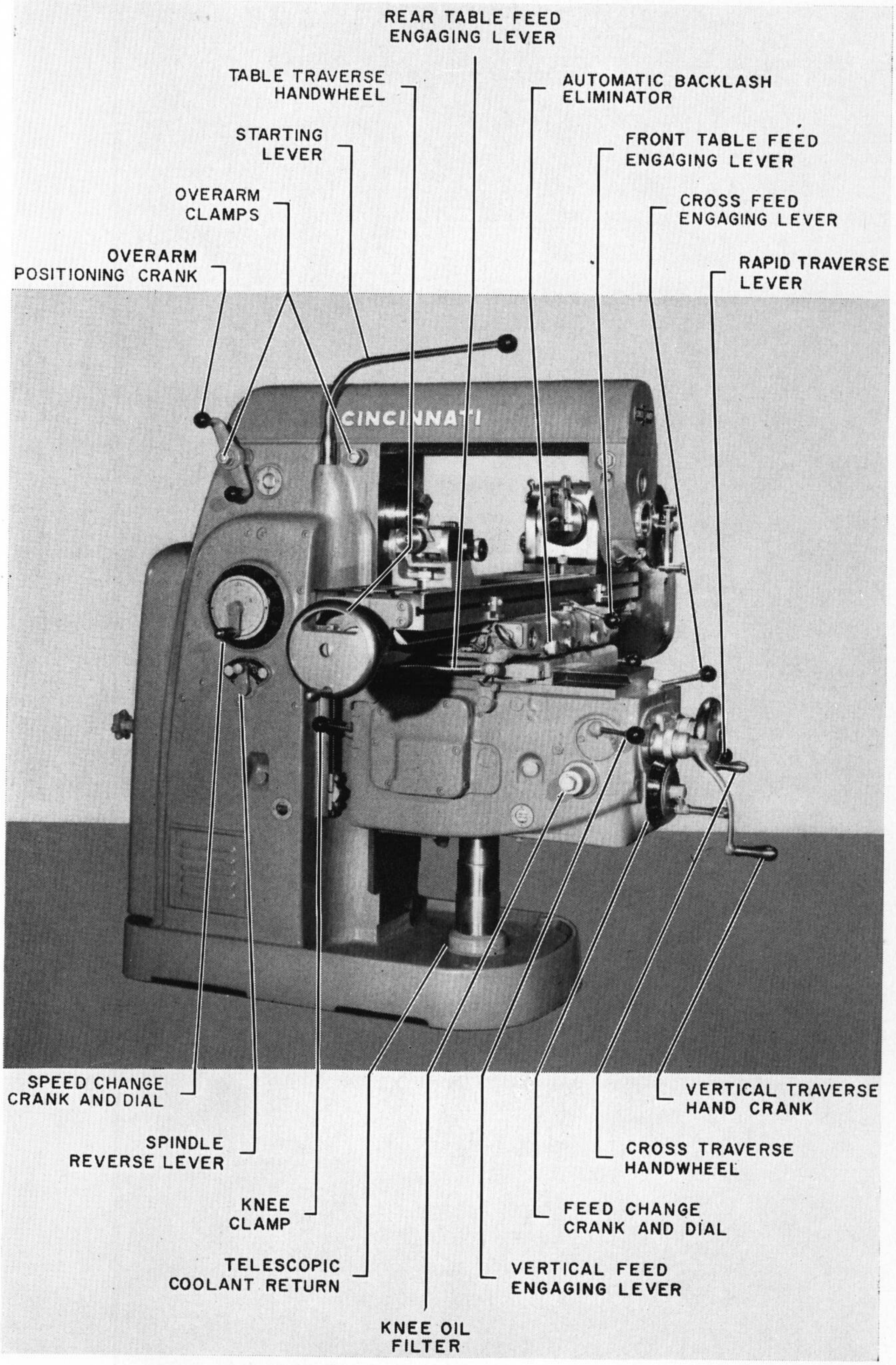

REAR TABLE FEED ENGAGING LEVER
TABLE TRAVERSE HANDWHEEL
AUTOMATIC BACKLASH ELIMINATOR
STARTING LEVER
FRONT TABLE FEED ENGAGING LEVER
OVERARM CLAMPS
CROSS FEED ENGAGING LEVER
OVERARM POSITIONING CRANK
RAPID TRAVERSE LEVER
CINCINNATI
SPEED CHANGE CRANK AND DIAL
VERTICAL TRAVERSE HAND CRANK
SPINDLE REVERSE LEVER
CROSS TRAVERSE HANDWHEEL
KNEE CLAMP
FEED CHANGE CRANK AND DIAL
TELESCOPIC COOLANT RETURN
VERTICAL FEED ENGAGING LEVER
KNEE OIL FILTER

Figure 27A
Functional Diagram

OPERATING INSTRUCTIONS

In general, these instructions apply to plain, universal and vertical machines. See pages 35 to 37 for instructions which apply to vertical machines only.

Starting the Machine. Place the cross, vertical, and table feed levers in their neutral or stop positions, as shown in Figure 33A. Make sure that the motor compartment door at the rear of the machine is closed and latched or the machine will not start. Move the spindle reverse lever (Figure 40A) to either the right or left position. To start the spindle rotation, press the start button (Figure 28A), and then move the starting lever to the right. The starting lever may be operated either from the right (Figure 28C) or left side of the machine (Figure 28B). A quick-acting brake automatically stops all moving members of the machine when the lever is moved to the left. To stop the drive motor, press the stop button on the right (Figure 28A).

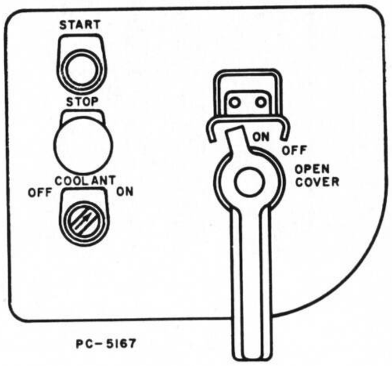


Figure 28A
Start-Stop Buttons

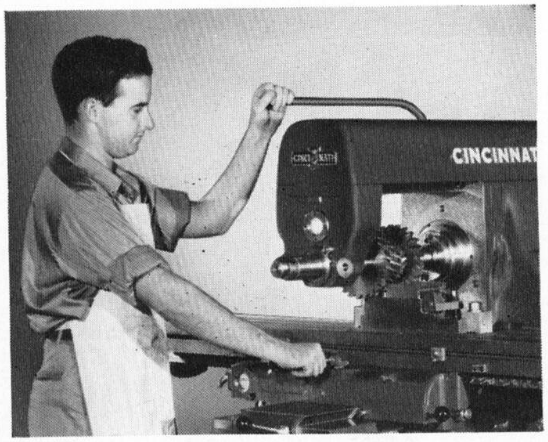


Figure 28B (Left)
Starting the Spindle when Working at the Left Side of the Machine

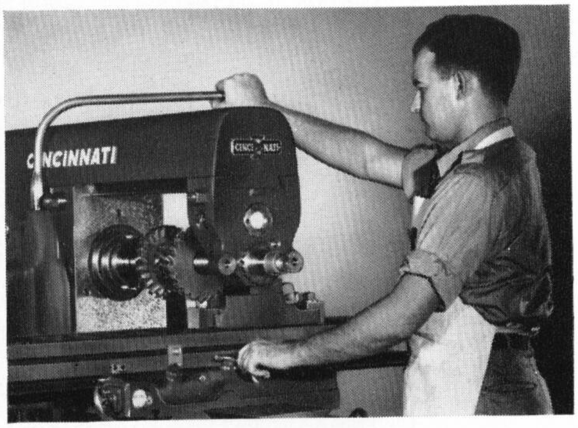


Figure 28C (Right)
Starting the Spindle when Working at the Right Side of the Machine

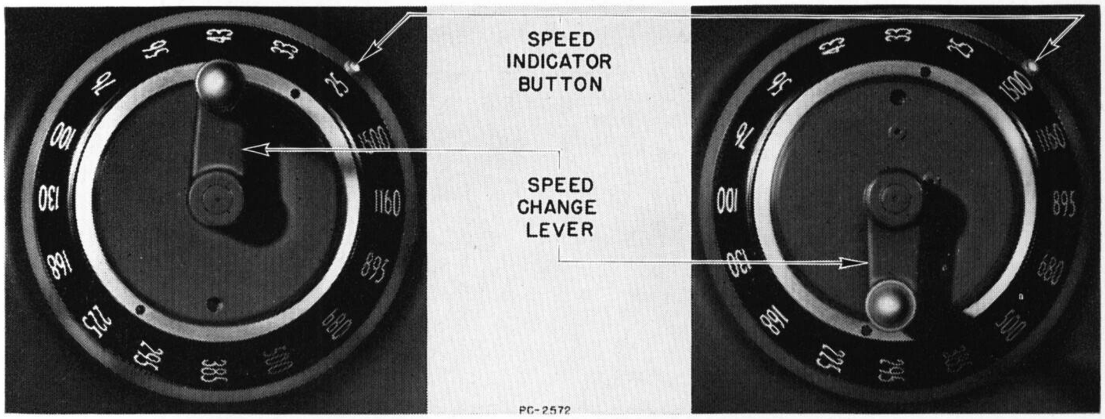


Figure 29A—Speed Change Lever and Dial—Horizontal Machines
Left—Speed Dial set for a Spindle Speed of 25 rpm;
Right—Speed Dial set for a Spindle Speed of 1500 rpm

Changing Spindle Speeds. Horizontal Machines. (For Vertical Machines, see page 35.) Start the motor. While the starting lever is in the stop position, pull out the handle of the speed change lever (Figure 29A) and move the lever either clockwise or counter-clockwise. Each half turn (180°) gives a speed change. When the desired speed matches the indicator button (for indication of speed, see Figure 29A) release the handle, engaging it in the hole provided. The two positions of the speed change lever are shown in Figure 29A. Speed changes may be easily made when working either at the front (Figure 29B) or at the rear of the machine (Figure 29C).

SPINDLE SPEEDS (rpm)

Standard Range	25	33	43	56	76	100	130	168	225	295	385	500	680	895	1160	1500
Low Range*	20	25	33	43	56	76	100	130	168	225	295	385	500	680	895	1200
High Range*	33	43	56	76	100	130	168	225	295	385	500	680	895	1160	1500	2000

*Can be supplied at time order is placed. 33 to 2000 is standard spindle speed for 410–14 machines.

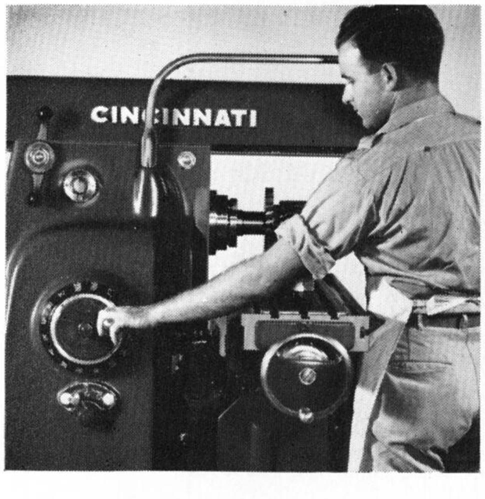


Figure 29B (Left) Changing Speeds when Working at Front of Machine

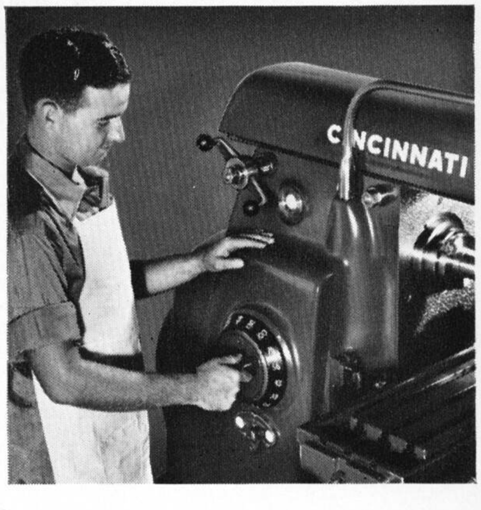


Figure 29C (Right) Changing Speeds when Working at Rear of Machine

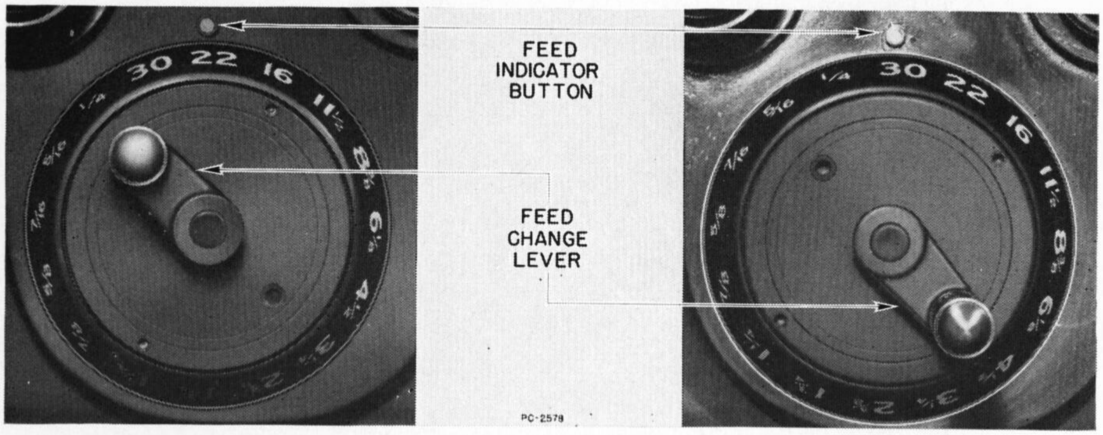


Figure 30A—Feed Change Lever and Dial
Left—Feed Dial set for Feed of 22 inches per minute;
Right—Feed Dial set for Feed of 30 inches per minute

Changing the Feed Rate. With the motor running and the spindle start-stop lever in the stop position, pull out the handle of the feed change lever (Figure 30A) and move the lever either clockwise or counter-clockwise. Each half turn (180°) of the lever gives a feed change. When the desired feed matches the indicator button (for indication of feed, see Figure 30A) release the handle, engaging it in the hole provided. The two positions of the feed change lever are shown in Figure 30A. Feed changes are made from a normal operating position at the front of the machine (Figure 30B).

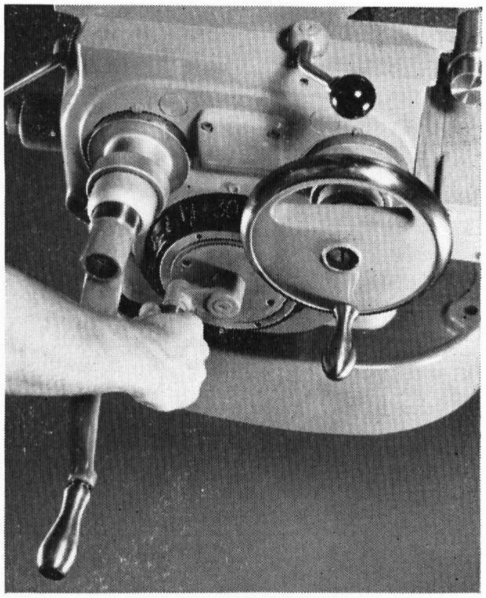


Figure 30B
Changing the Feed Rates

Note: Change feeds only when all power feed levers are in their neutral positions (see Figure 33A).

FEEDS (inches per minute)

Standard Feed Range (1/4″ to 30″)

Longitudinal and Cross	1/4	5/16	7/16	5/8	7/8	1 1/4	1 3/4	2 3/8	3 1/4	4 1/2	6 1/8	8 3/8	11 1/2	16	22	30
Vertical	1/8	5/32	7/32	5/16	7/16	5/8	7/8	1 3/16	1 5/8	2 1/4	3 1/16	4 3/16	5 3/4	8	11	15

Micrometer Dials. All of the hand controls—table, cross, and vertical—are equipped with adjustable micrometer dials. These dials may be easily reset by merely pulling them out against a light spring pressure and rotating them to the desired marking (Figure 31A).

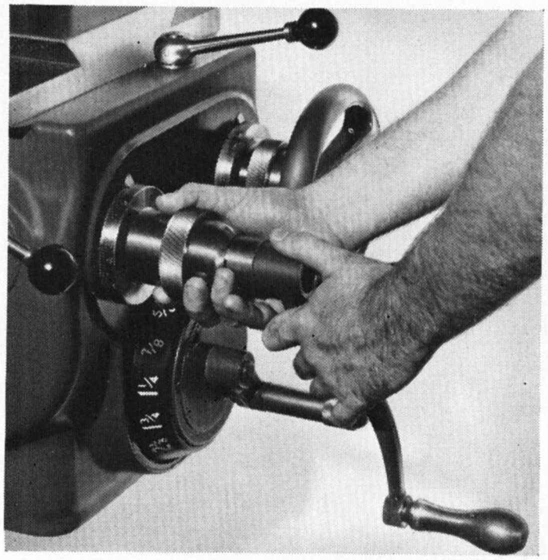


Figure 31A
Resetting the Micrometer Dial

Table Traverse Handwheel. The handwheel shown in Figure 31B is for moving the table by hand when the power feed is disengaged. When the handwheel is rotated one turn in a clockwise direction the table moves to the right ¼ inch. The dial is graduated into 250 equal spaces, which is equivalent to .001″ movement for each space. To use the hand table traverse, push in the handwheel until you feel the clutch teeth mesh. The clutch is automatically disengaged when the table power feed lever is moved to a feed position.

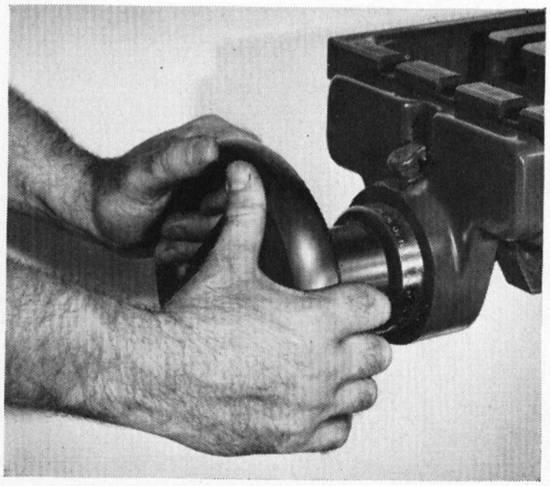


Figure 31B
Table Traverse Handwheel

Cross Traverse Handwheel. The handwheel shown in Figure 32A is for moving the saddle by hand across the top of the knee. One turn clockwise of the handwheel moves the saddle ¼ inch toward the column. The micrometer dial is graduated into 250 equal spaces, which is equivalent to .001″ movement for each space. To use the hand cross traverse, push in the handwheel until you feel the clutch teeth mesh. The clutch is automatically disengaged when the cross power feed lever is moved to a feed position.

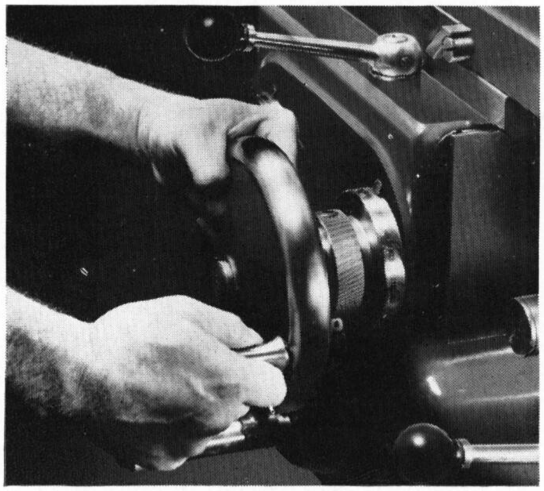


Figure 32A
Cross Traverse Handwheel

Vertical Traverse Handcrank. Figure 32B shows the crank for moving the knee up and down. One turn clockwise of the crank raises the knee ⅛ inch. The micrometer dial is graduated into 125 equal spaces, which is equivalent to .001″ movement for each space. To use the hand vertical traverse, push in the crank until you feel the clutch teeth mesh. The clutch is automatically disengaged when the vertical power feed lever is moved to a feed position.

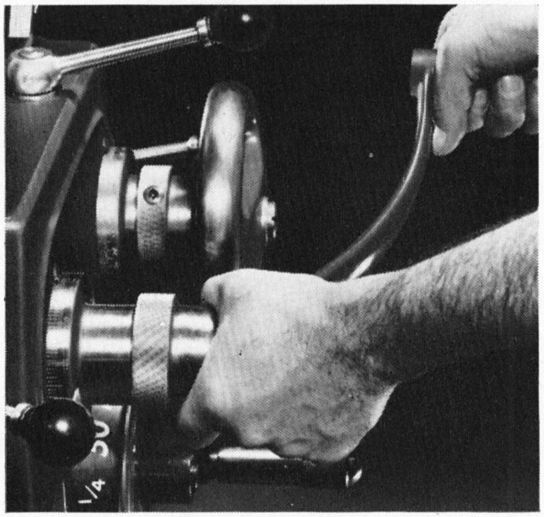


Figure 32B
Vertical Traverse Handcrank

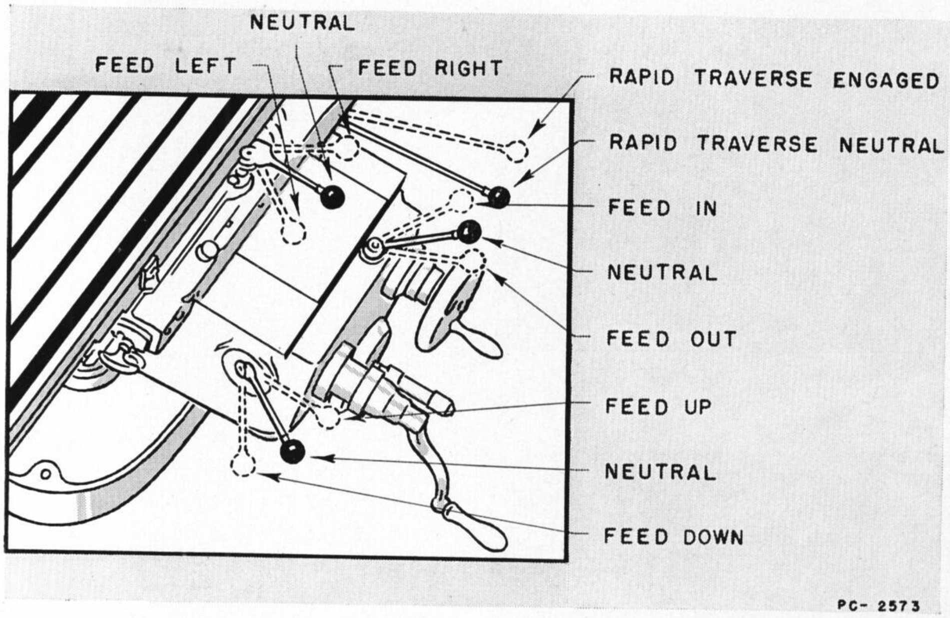


Figure 33A
Engaged and Neutral Positions of Front Control Power Feed Levers

Power Feed Levers. All power feed levers—table, cross, and vertical—are directional control levers; that is, the sliding unit moves in the direction in which the lever is moved. For instance, if the table feed lever is moved to the right, the table feeds right. If the lever is moved to the left, the table feeds left (see Figure 33A).

Warning: If you hear a clicking or snapping noise when the machine is in feed or rapid traverse, *immediately* stop the machine. This noise is the safety gear slipping due to interference between the fixture and arbor support, fixture and arbor, fixture and column, etc. The safety gear will also slip if the feed rate is too high.

Power Table Feed. The lever shown in Figure 33B is for engaging the power table feed when working at the front of the machine, while the lever in Figure 33C is for engaging the table feed when working at the rear. Be certain that you loosen the table clamping screws before engaging the table feed; and it is also advisable to tighten the knee and saddle clamps when using the table feed alone. (See Clamping Devices for Sliding Units, pages 38-39).

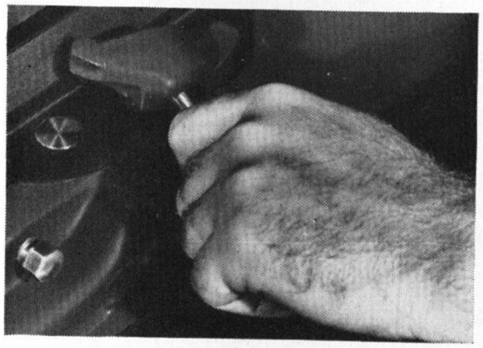


Figure 33B
Engaging the Front Power Table Feed Lever

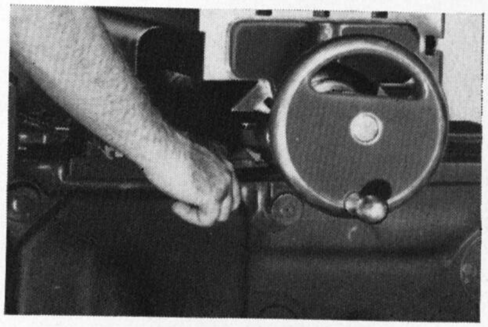


Figure 33C
Engaging the Rear Power Table Feed Lever

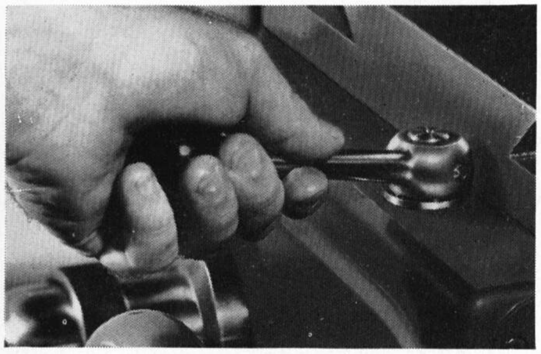


Figure 34A
Power Cross Feed Lever

Power Cross Feed. Figure 34A shows the lever for engaging the cross feed. Before engaging the cross feed, loosen the saddle clamp. It is also advisable to tighten the table clamping screws and the knee clamp when using the cross feed alone. (See Clamping Devices for Sliding Units, pages 38-39).

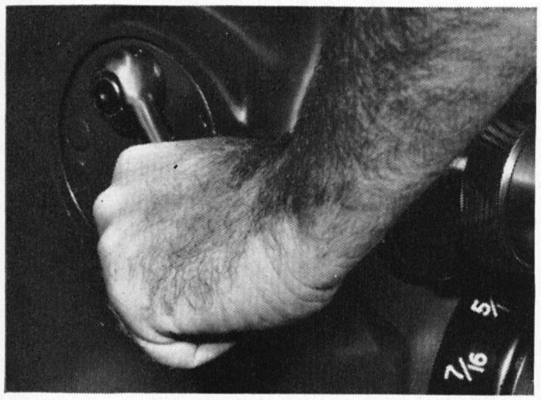


Figure 34B
Power Vertical Feed Lever

Power Vertical Feed. Engaging the power vertical feed is accomplished through the lever shown in Figure 34B. Before engaging the vertical feed, loosen the knee clamp. It is also advisable to tighten the table clamping screws and the saddle clamp when using the vertical feed alone. (See Clamping Devices for Sliding Units, pages 38-39).

Power Rapid Traverse. Power rapid traverse may be engaged at any time for any direction of travel with the spindle running or stationary. (Of course, the motor must be running.) The feed lever which will give you the direction of travel desired must also be engaged at the same time the rapid traverse lever is engaged.

For instance, suppose you want to use the table rapid traverse. Move the table feed lever to the right or left, according to the direction of travel desired. Then pull up the rapid traverse lever (see Figure 36B) to its engaged position. The sequence of engaging the levers is an important consideration in long life of the rapid traverse clutch—*always engage the feed lever first and then the rapid traverse lever.*

Releasing the rapid traverse lever instantly changes the rate of travel from rapid traverse to feed in the same direction.

Rapid traverse for the longitudinal and cross movement is 150 inches per minute and the vertical movement is 75 inches per minute.

OPERATING INSTRUCTIONS

Common to No. 205-10 MI Vertical Machines Only. Remainder of Operating Instructions are same as for Horizontal Machines

Changing Spindle Speeds. Vertical Machines. Start the motor. While the starting lever is in the stop position, pull out the handle of the speed change lever (Figure 35B) and move it either clockwise or counter-clockwise. When the desired speed matches the indicator button (for indication of speed, see Figure 35B) release the handle, engaging it in the hole provided. The two positions of the speed change lever are shown in Figure 35B. Then shift the back gear lever (Figure 35A) into "A" or "B" positions as indicated on the dial. Do not shift the back gear lever unless the motor is running and the spindle is stopped. If the back gear lever does not shift easily, jog the spindle with the starting lever.

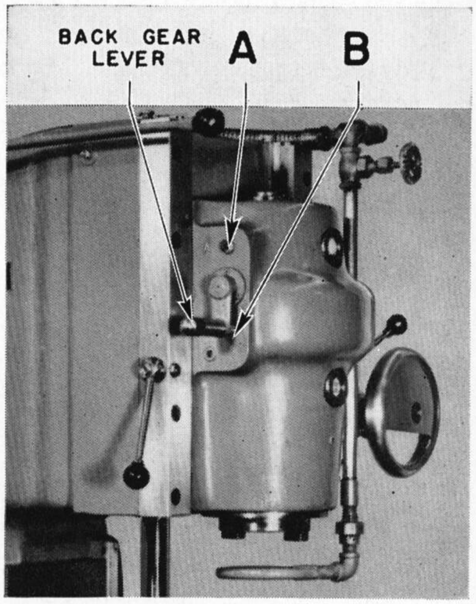


Figure 35A
Back Gear Lever

SPINDLE SPEEDS (rpm)

Position of Back Gear Lever	A	A	A	A	A	A	A	A	B	B	B	B	B	B	B	B
Standard Range	25	33	43	56	76	100	130	168	225	295	385	500	680	895	1160	1500
Low Range*	20	25	33	43	56	76	100	130	168	225	295	385	500	680	895	1200
High Range*	33	43	56	76	100	130	168	225	295	385	500	680	895	1160	1500	2000

*Can be supplied at time order is placed.

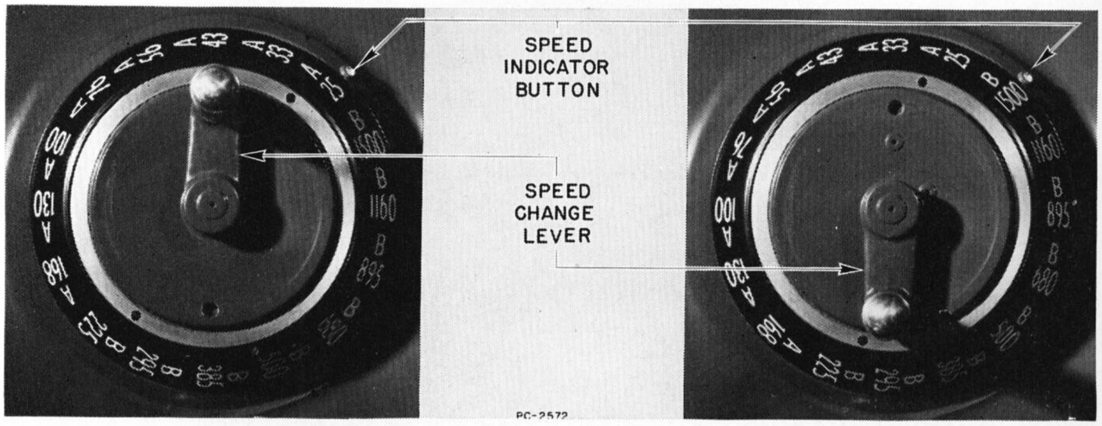


Figure 35B—Speed Change Lever and Dial—No. 205-10 MI Vertical
Left—Speed Dial Set for Spindle Speed of 25 rpm—Back Gear Lever should be set at "A".
Right—Speed Dial Set for a Spindle Speed of 1500 rpm—Back Gear Lever should be set at "B".

Hand Feed to Head. The handwheel shown in Figure 36A is for moving the vertical head up and down by hand. One clockwise turn of the handwheel moves the head down ⅛". The micrometer dial is graduated into 125 spaces, which is equivalent to .001" movement for each space. Be sure that you loosen the hand clamp (Figure 37A) before moving the vertical head.

Power Feed to Head. The lever shown in Figure 36A is for engaging the power vertical feed. When the lever is moved up, the vertical head moves up; when the lever is moved down, the head moves down. Be certain that you loosen the hand clamp before engaging the power feed.

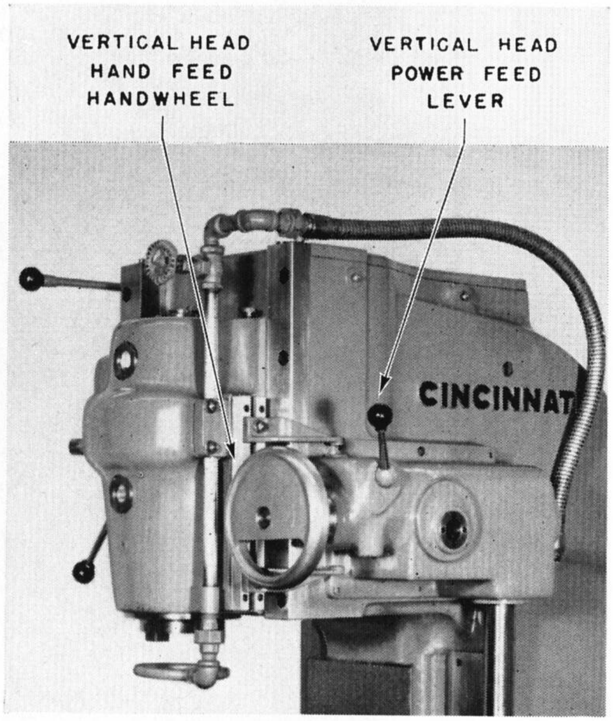

VERTICAL HEAD HAND FEED HANDWHEEL
VERTICAL HEAD POWER FEED LEVER
CINCINNAT

Figure 36A
Hand and Power Feed Levers
Four-Position Turret Stop (Std. Equipment)
Not Shown in Above Illustration

FEEDS (inches per minute)

Standard Feed Range (¼" to 30")

Feed Indicated on Dial	¼	5/16	7/16	⅝	⅞	1¼	1¾	2⅜	3¼	4½	6⅛	8⅜	11½	16	22	30
Actual Feed to Head	⅛	5/32	7/32	5/16	7/16	⅝	⅞	1 3/16	1⅝	2¼	3 1/16	4 3/16	5¾	8	11	15

Power Rapid Traverse to Head. The power rapid traverse is controlled by the feed lever shown in Figure 36A and the regular rapid traverse lever shown in Figure 36B. Move the feed lever in the direction you want the head to move and then pull up the rapid traverse lever. The rapid movement of the vertical head is 75 inches per minute.

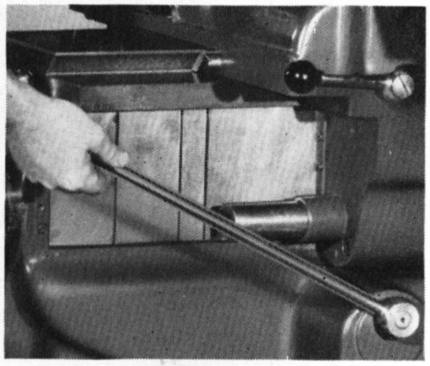


Figure 36B
Power Rapid Traverse Lever

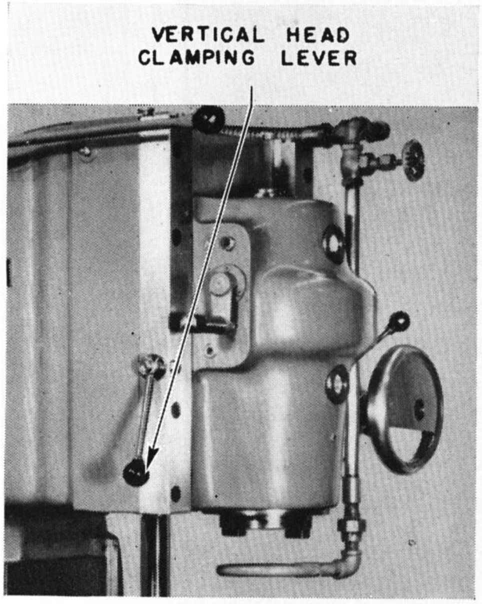


Figure 37A
Vertical Head Clamping Lever

Clamping the Head in Position. The hand clamping lever shown in Figure 37A is for clamping the vertical head in position. Be sure that you loosen this clamp before moving the head by hand or engaging the power feed or rapid traverse.

Four-Position Turret Stop and Dial Indicator. The turret stop and dial indicator are shown in Figure 37B. Downward power rapid traverse movement of the head should be disengaged before the turret stop screw contacts the plunger at the top of the indicator bracket. Failure to do so may result in a wreck, as the head may "coast" after tripping the plunger. The turret stop screw should be used as a feed trip only. After tripping, the head should be adjusted to the final position by hand while noting the dial indicator reading. The trip dog shown in Figure 37B is for disengaging the upward power movement of the head.

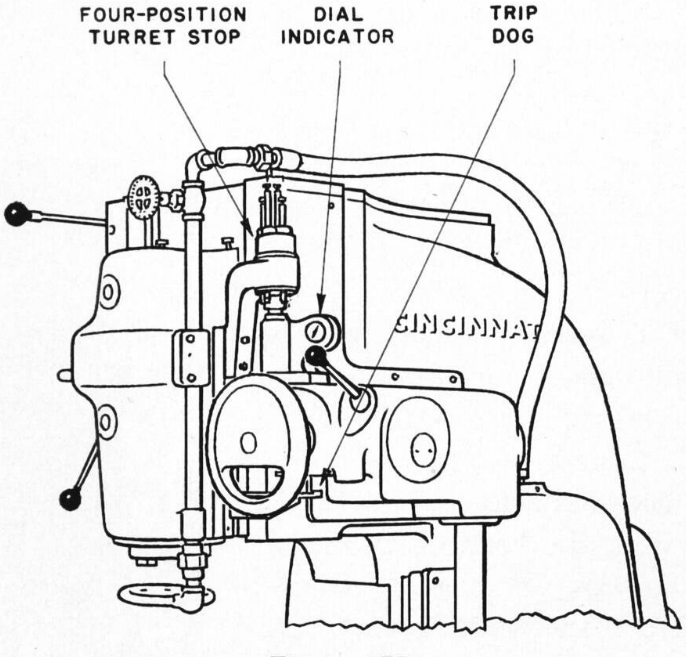


Figure 37B
Four-Position Turret Stop and Dial Indicator

SETTING UP THE MACHINE

Setting up the Fixture and Cutters. Clamp the fixture in the center of the table, or as near the center as operating conditions will permit, to avoid as much as possible the excessive overhang of the table which causes wear on the ends of the table gibs. If you are using a lathe dog for holding the work, do not under any condition use the T-slots of the table for tightening the dog screw. When these T-slots become marred, the work or fixture which is located from them will not line up properly, with the result that a new table must be purchased or the old one replaned to obtain accurate work.

When using a cutter on an arbor, the cutter must fit accurately and the arbor must run true between dead centers to obtain the best finish on the work and freedom from chatter. The cutter must be a snug fit on the arbor for the same reason. The ends of the spacing collar and arbor nut must be perfectly clean before assembling, because dirt particles between the collars will spring the arbor when the nut is tightened. Always use as short an arbor as possible, and space the cutter as near to the spindle as operating conditions will permit.

When placing a face mill on the spindle nose of a vertical machine, the best method is to place the mill on a block of wood resting on the table, and then raise the knee until the face mill will slip over the spindle nose without undue physical exertion. Tighten each face mill screw a fraction of a turn until they are all tight. A crane can be used to suspend the face mill when mounting it on the spindle nose of horizontal machines. Arbor-Loc Spindle Nose must be removed when using face mills.

Overarm, Supports, and Brace. A pilot wheel is provided to move the overarm. The overarm is equipped with a Dynapoise vibration damper unit, which practically eliminates the need for the brace (Figures 8A, 10A and 14A) which is supplied with horizontal machines.

Clamping Devices for Sliding Units. The table, knee, saddle, or housing may be clamped in position by tightening the screws and levers shown in Figures 39A, 39B, 39C, and 39D. Two screws are provided for clamping the table to the saddle (Figure 39A), one lever for clamping the knee to the column (Figure 39B), one lever for clamping the saddle to the knee (Figure 39C), and four screws (two at front of housing (Figure 39D) and two at rear) for clamping the housing to the saddle of universal machines.

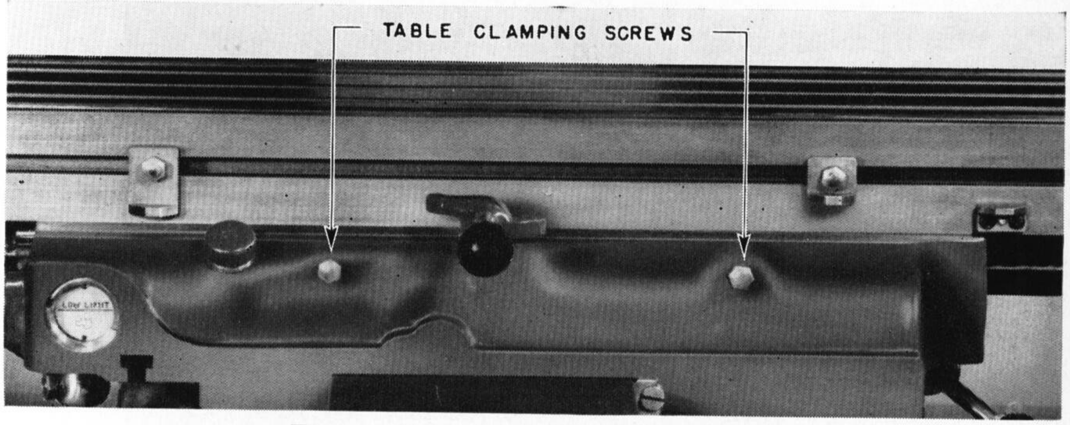


Figure 39A—Table Clamping Screws

The sole purpose of these screws and levers is to firmly tighten the units which are not in motion during the machining operation. For example, if you are using the table feed alone, tighten the saddle, housing, and knee clamping devices. The rigidity of the machines as a whole will thereby be increased, and tendency to chatter eliminated or correspondingly reduced.

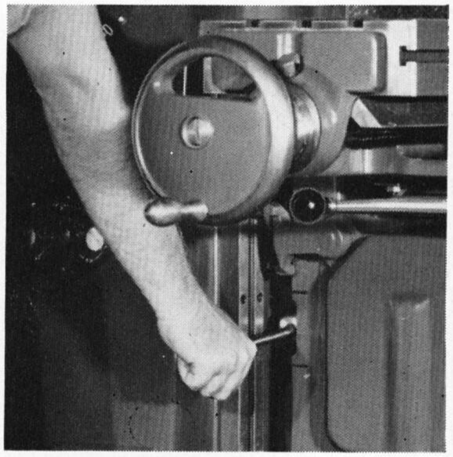


Figure 39B
Knee Clamping Lever

Under no conditions are you justified in using these devices as a method of adjustment for wear. Obviously, such a practice would result in rapid wear in the spots at which the pressure from the screws is applied, and there is also a greater possibility of the bearings scoring, because of the concentrated pressures. Taper gibs are provided for adjustment to compensate for wear. (See page 48).

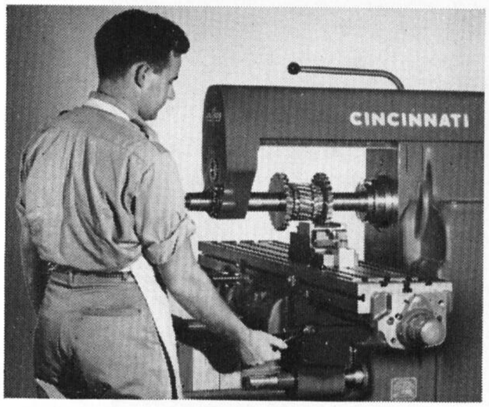


Figure 39C
Saddle Clamping Lever

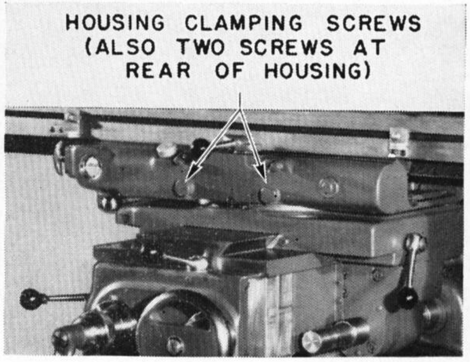


Figure 39D
Housing Clamping Screws

Reversing the Direction of Rotation of the Spindle. Spindle rotation must be the same as the "hand" of the cutter; that is, the rotation must be clockwise for a "right-hand" cutter and counter-clockwise for a "left-hand" cutter. The direction of rotation is controlled by the lever shown in Figure 40A.

Note that RIGHT and LEFT on the spindle reverse plate indicate the direction of rotation of the spindle when viewed from the rear end of the spindle.

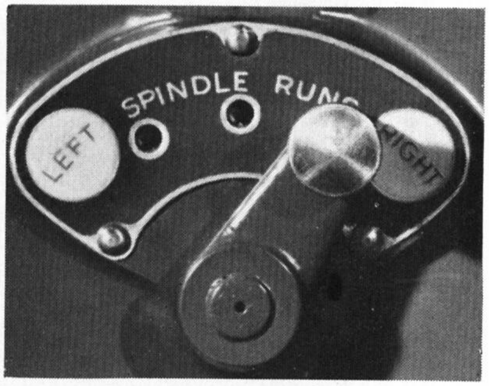


Figure 40A
Spindle Reverse Lever

Feed Trip Dogs. Trip dogs are provided for automatically stopping the power table, cross, or vertical feeds at the end of the cut or at any desired point in the travel of the unit. (See pages 42-47 for automatic cycle machines).

The table feed trip dogs shown in Figure 40B will not trip unless the long dog is at the left of the table feed engaging lever, and the short dog at the right. Should the operator position the dogs incorrectly, two positive stop dogs, one at each end of the table, prevent the table from traveling too far in power feed; eliminating the possible injury to the mechanism.

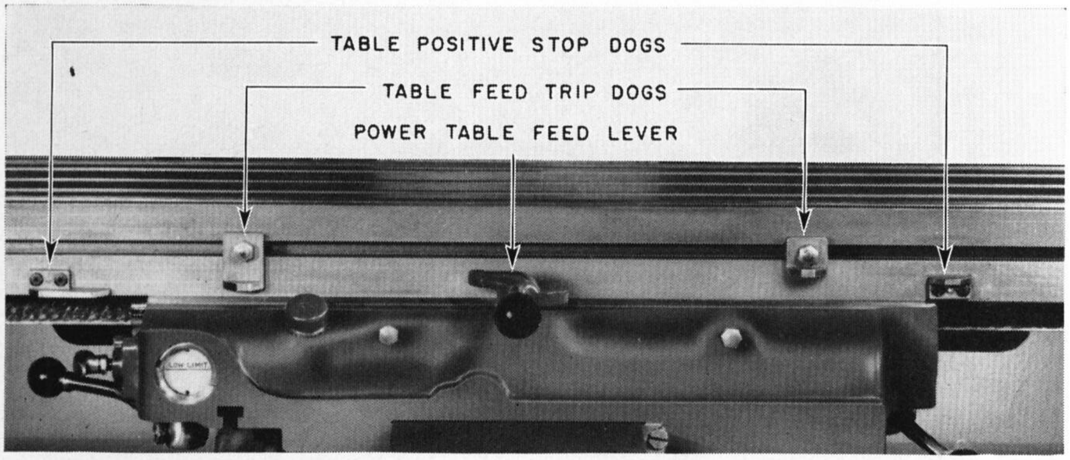


Figure 40B
Table Feed Trip Dogs and Stop Dogs

The feed trip dogs shown in Figure 41A are for automatically stopping the saddle at any desired point in the cross travel. Safety dogs are provided to limit the position for setting the trip dogs. Do not remove these safety dogs in order to obtain a greater range of travel.

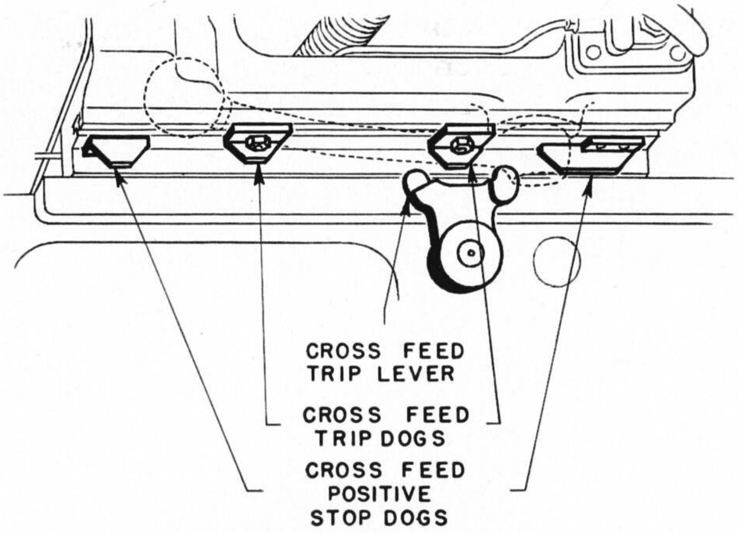


Figure 41A
Cross Feed Trip Dogs and Stop Dogs
Under the Left-hand End of the Saddle

Figure 41B shows the feed trip dogs for automatically stopping the knee at any desired point in the vertical travel. Positive stop dogs are provided as a safety measure to prevent the trip dogs being set beyond the actual range of the knee.

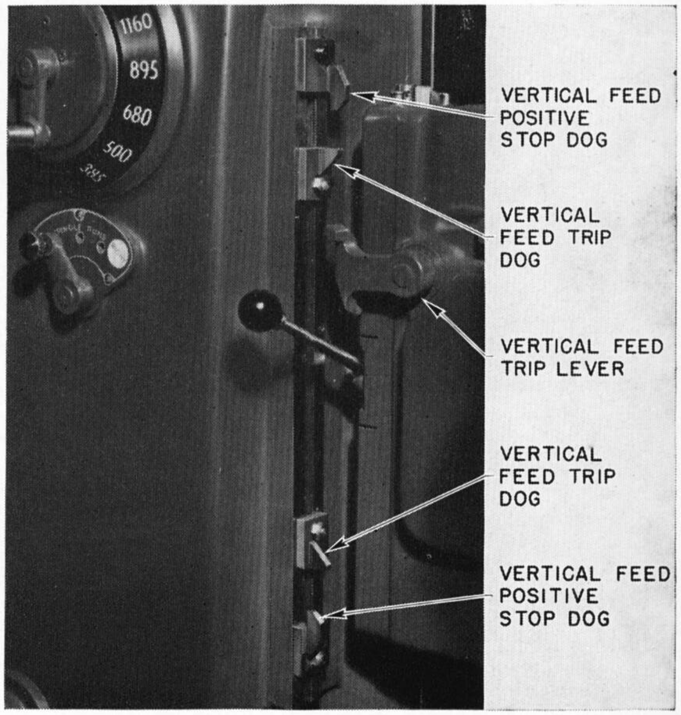


Figure 41B
Vertical Feed Trip Dogs and Stop Dogs

Changing from Steel to Cast Iron Jobs. When milling a material which does not require a cutting fluid, such as cast iron or aluminum, all strainers should be protected with the covers provided for them to keep fine chips and particles of metal out of the cutting fluid system. Do not use compressed air for cleaning the machine when setting up for a new job. The chips may be blown into the bearings, resulting in untimely wear.

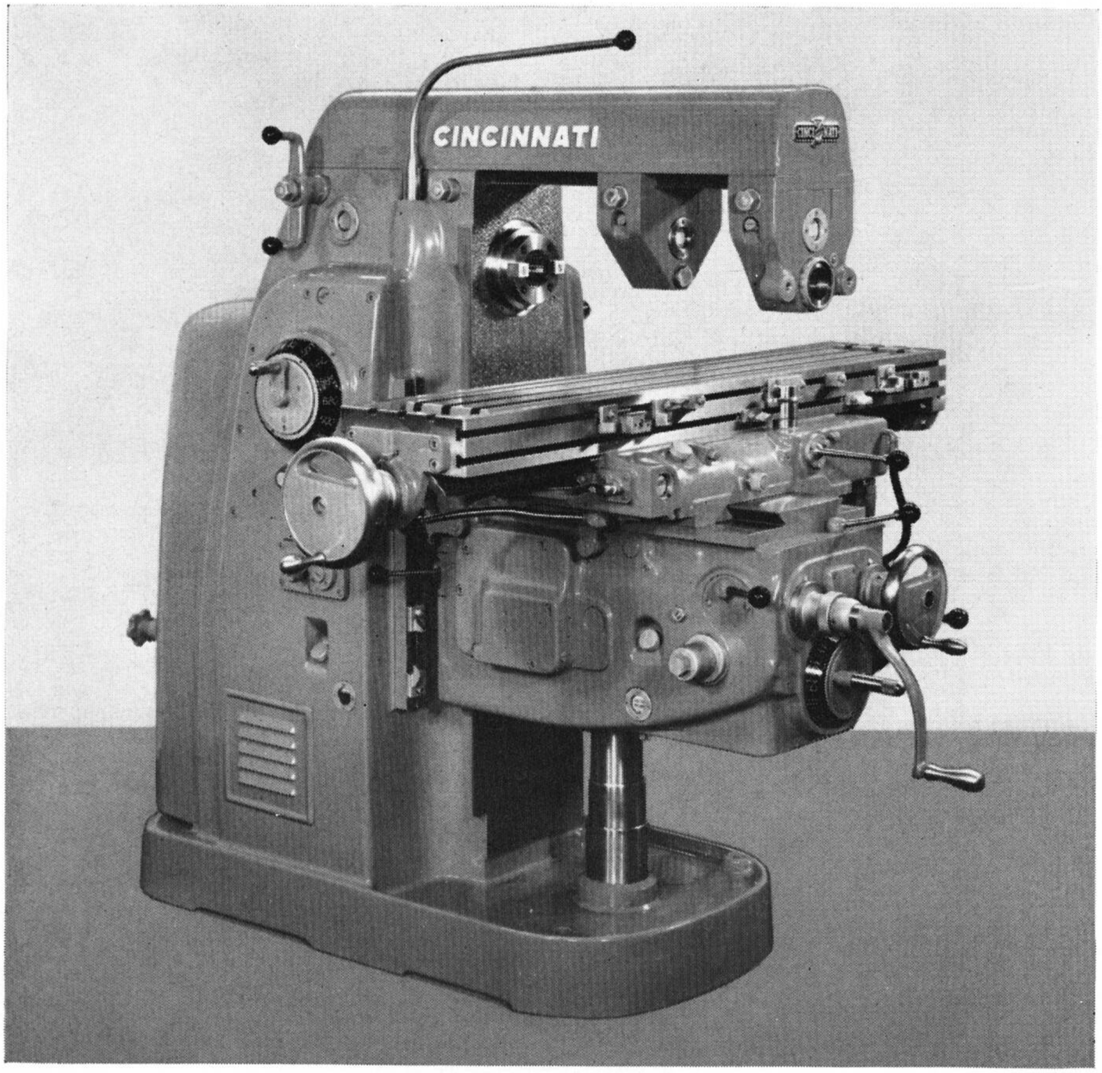


Figure 42A
No. 205-10 MI Plain Milling Machine
with Automatic Cycle

Automatic Table Cycles for ML and MI Milling Machines. Standard MI Milling Machines, without Automatic Cycle, have a three-position table control lever and table dogs which act only to stop the table movement out of feed in either direction. When these machines are provided with Automatic Cycle, a five-position table control lever is provided for hand control of table movements and table dogs act to provide completely automatic shifting from feed to rapid traverse, rapid traverse to feed, feed to rapid traverse in opposite direction, and feed to stop. Eight adjustable table control dogs are supplied with the Automatic Cycle; 2 feed dogs, 2 rapid traverse dogs, 2 reverse dogs, 1 stop dog, and 1 safety stop dog.

In addition, the extreme positions of table movement in either direction are limited by two dogs permanently pinned to the front of the table. These dogs provide a safety measure to prevent power movements of the table beyond its actual operating range.

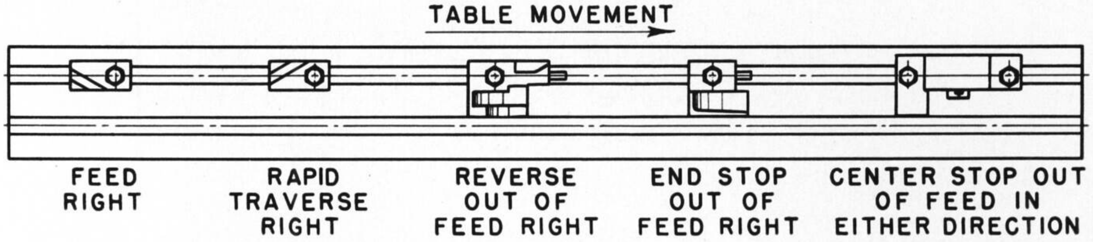


TABLE MOVEMENT
FEED RIGHT
RAPID TRAVERSE RIGHT
REVERSE OUT OF FEED RIGHT
END STOP OUT OF FEED RIGHT
CENTER STOP OUT OF FEED IN EITHER DIRECTION

Figure 43A
Dogs Which Act with Table Moving to the Right

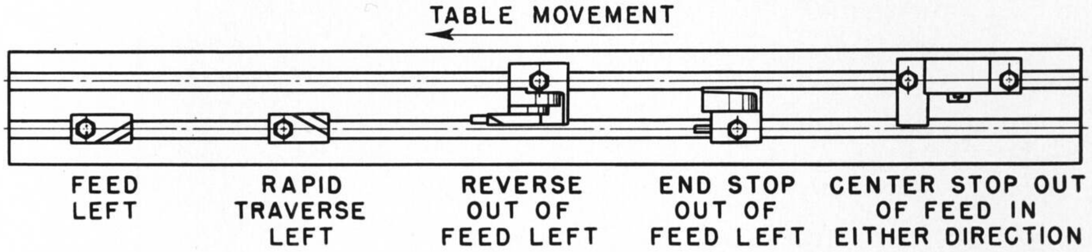


TABLE MOVEMENT
FEED LEFT
RAPID TRAVERSE LEFT
REVERSE OUT OF FEED LEFT
END STOP OUT OF FEED LEFT
CENTER STOP OUT OF FEED IN EITHER DIRECTION

Figure 43B
Dogs Which Act with Table Moving to the Left

The feed dogs and rapid traverse dogs are of the same pattern, their function being merely to raise or lower the dog trip plunger. The upper position of the trip plunger initiates the feed rate, the lower position initiates the rapid traverse rate. Of the four dogs supplied, two are right-hand; two are left-hand. These dogs are used in the upper dog slot to control table movement to the right; in the lower dog slot to control table movements to the left.

The reverse dogs reverse the table from feed to rapid traverse in the opposite direction. One left-hand and one right-hand dog are supplied. Both dogs are mounted in the upper dog slot.

The stop dog acts to stop the table from feed. It is non-directional and can be used to trip the table out of feed in either direction. When mounted in upper dog slot it stops table when feeding to the right, when mounted in lower slot it stops table when feeding to the left.

The safety stop dog also acts to stop the table from feed in either direction, but is supplied particularly to provide an automatic safety stop in the center of an automatic reciprocating cycle. It is mounted in the upper dog slot and acts to stop the table from both directions of feed.

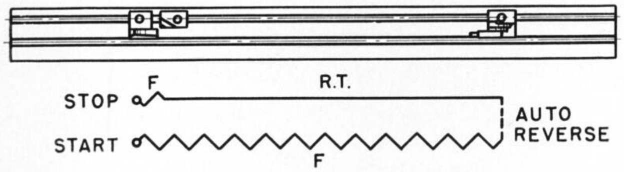
On Automatic Cycle machines, the action of the rapid traverse control lever on the side of the knee is independent of the table control lever. When the table control lever is shifted, by hand or by the table dogs, into the rapid traverse position, the rapid traverse lever is not affected but remains in the neutral position. Conversely, if the table control lever is in the feed position, engaging the rapid traverse lever will put the table in rapid traverse without changing the position of the table control lever.

The cycle drawings on the following page illustrate just a few of the many useful automatic cycles which can be obtained. Cycles can progress in either direction or, as in the case of the automatic reciprocating cycle, in both directions.

In reading the cycle drawings, they progress in the opposite direction to the actual table movement, as this illustrates the relative movement between the trip plunger and the trip dogs so that the dog can be shown directly above the cycle function it controls.

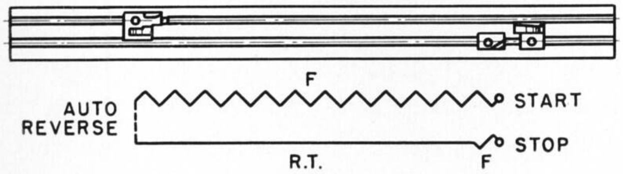
The short feed stroke at the end of some rapid traverse strokes is used to permit the table to be automatically stopped. If you have a cycle requiring more than one automatic stop, the second stop can be accomplished by using the center safety stop dog.

Cycles are started by shifting the table control lever to give the desired movement.



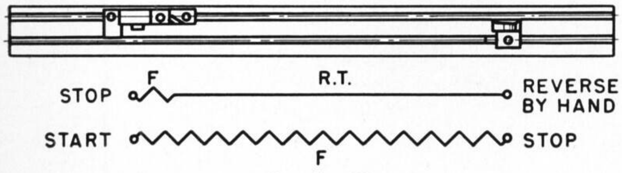
Cycle A

Simple milling cycle, automatic reverse and rapid return feeding left. Feed left, automatic reverse, rapid traverse right, short feed right, stop.



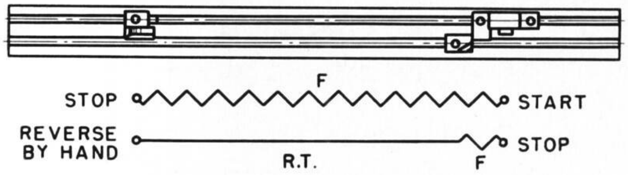
Cycle B

Simple milling cycle, automatic reverse and rapid return, feeding right. Feed right, automatic reverse, rapid traverse left, short feed left, stop.



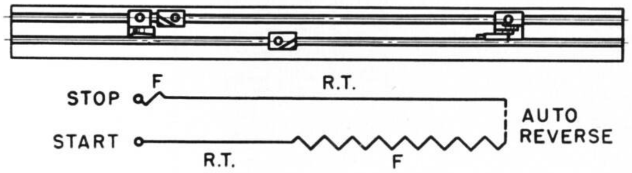
Cycle C

Simple milling cycle, feed to stop, hand controlled reverse and rapid return, feeding left. Feed left, automatic stop, reverse by hand, rapid traverse right, short feed right, stop.



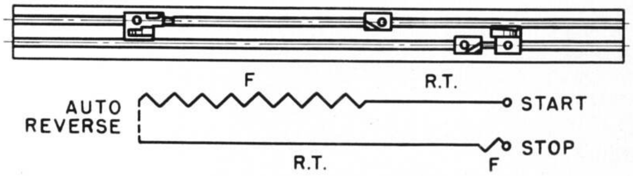
Cycle D

Simple milling cycle, feed to stop, hand controlled reverse and rapid return, feeding right. Feed right, automatic stop, reverse by hand, rapid traverse left, short feed left, stop.



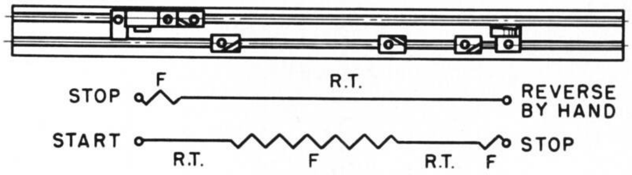
Cycle E

Simple milling cycle, rapid approach, automatic reverse and rapid return, feeding left. Rapid traverse left, feed left, automatic reverse, rapid traverse right, short feed right, stop.



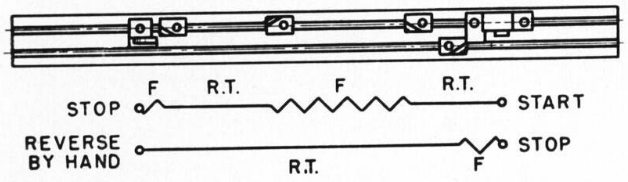
Cycle F

Simple milling cycle, rapid approach, automatic reverse and rapid return, feeding right. Rapid traverse right, feed right, automatic reverse, rapid traverse left, short feed left, stop.



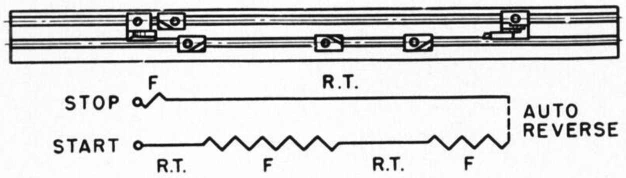
Cycle G

Simple milling cycle, rapid approach, rapid traverse to clear cutter, hand controlled reverse and rapid return, feeding left. Rapid traverse left, feed left, rapid traverse left, short feed left, stop, reverse by hand, rapid traverse right, short feed right, stop.



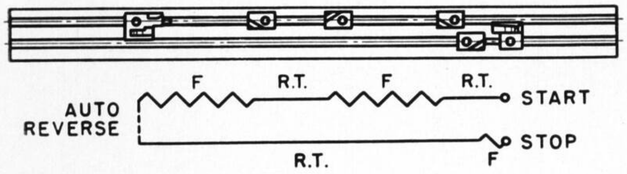
Cycle H

Simple milling cycle, rapid approach, rapid traverse to clear cutter, hand controlled reverse and rapid return, feeding right. Rapid traverse right, feed right, rapid traverse right, short feed right, stop, reverse by hand, rapid traverse left, short feed left, stop.



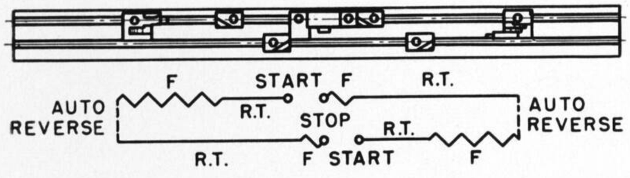
Cycle J

Intermittent feed cycle, rapid approach, automatic reverse and rapid return, feeding left. Rapid traverse left, feed left, rapid traverse left, feed left, automatic reverse, rapid traverse right, short feed right, stop.



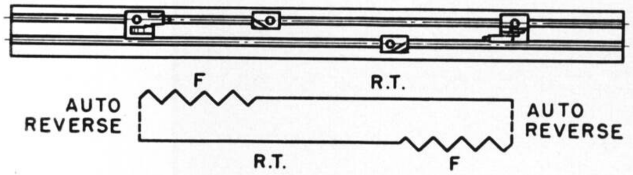
Cycle K

Intermittent feed cycle, rapid approach, automatic reverse and rapid return, feeding right. Rapid traverse right, feed right, rapid traverse right, feed right, automatic reverse, rapid traverse left, short feed left, stop.



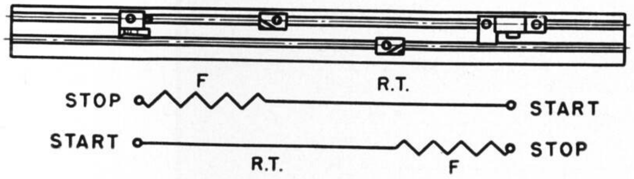
Cycle L

Reciprocating cycle, rapid approach, automatic reverse and rapid return, feeding both right and left, with center safety stop. Rapid traverse left, feed left, automatic reverse, rapid traverse right, short feed right, stop. Rapid traverse right, feed right, automatic reverse, rapid traverse left, short feed left, stop.



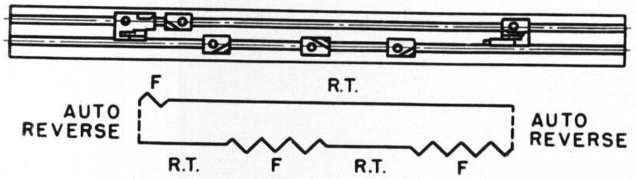
Cycle M

Continuous reciprocating cycle, rapid approach, automatic reverse, feeding both right and left. Rapid traverse left, feed left, automatic reverse, rapid traverse right, feed right, automatic reverse, and repeat the foregoing steps continuously.



Cycle N

Reciprocating cycle, rapid approach, stop at each end, feeding both left and right. Rapid traverse left, feed left, stop, reverse by hand, rapid traverse right, feed right, stop.



Cycle O

Continuous intermittent cycle, rapid approach, automatic reverse and rapid return, feeding left. Rapid traverse left, feed left, rapid traverse left, feed left, automatic reverse, rapid traverse right, short feed right, automatic reverse and repeat foregoing steps continuously.

ADJUSTMENTS

Adjusting the Gibs. Headless type taper gibs are provided to compensate for wear of the bearing surfaces between the sliding elements. Keep the bearing surfaces clean to avoid undue wear caused by dirt and grit.

1. See that the power feed engaging lever of the unit containing the gib to be adjusted is in the neutral position.
2. Turn the adjusting screw (Fig. 48A) to tighten the gib. Try movement of the unit by hand. Alternately tighten the screw and try by hand until unit is fairly tight, back screw away two turns, and then advance one turn.

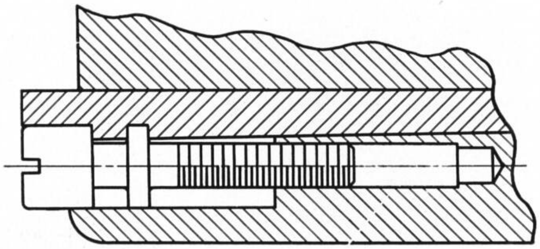


Figure 48A
Section Through Headless Type Gib

When adjustment of the gibs is necessary, they should never be drawn up so tightly as to prohibit free movement of the particular unit by means of the hand crank. Tight adjustment squeezes out the oil film, resulting in rapid wear.

Adjusting the Driving Clutch. The adjustment for the main drive clutch is located inside the driven sheave (Figure 48B). If the clutch slips under normal load, it should be adjusted as soon as possible to prevent excessive wear.

1. Open the motor compartment door.
2. Pull out the spring loaded adjustment pin (Figure 48B) and turn adjusting yoke clockwise until operating lever requires distinct pressure to engage. Be sure adjustment pin re-engages in one of the holes provided.
3. Close the motor compartment door.

If the spindle rotates slowly when the starting lever is in the stop position, the clutch is too tight and should be readjusted by pulling out the adjustment pin and turning the yoke counter-clockwise.

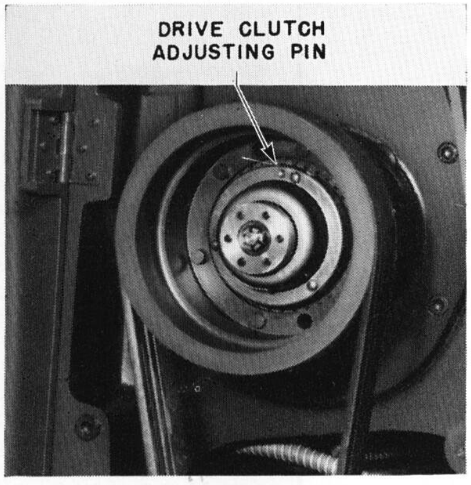


Figure 48B
Drive Clutch Adjusting Pin

Adjusting the Lead Screw Bearing. The lead (table feed) screw of these millers is provided with two tapered roller bearings at the right-hand end. When adjustment is necessary, proceed as follows:

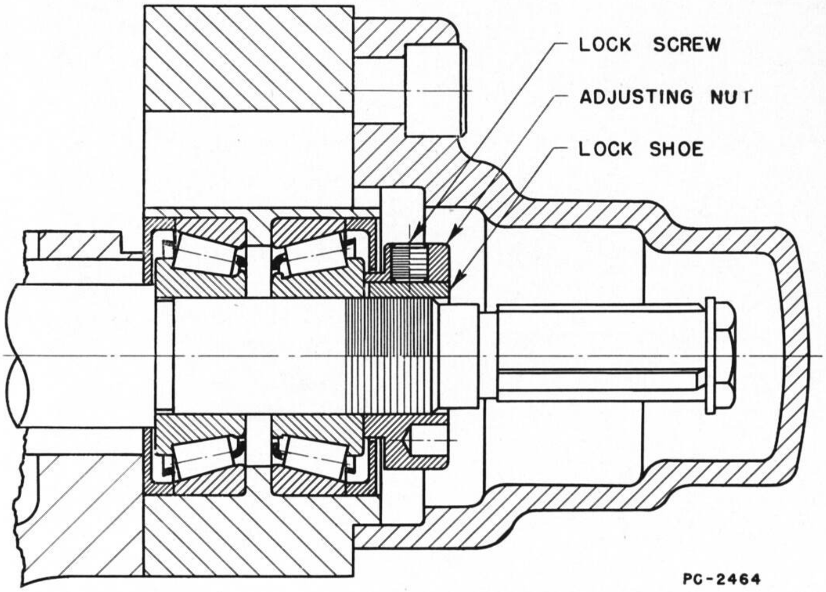


Figure 49A
Section Through Right Hand End of Table Feed Screw Mounting

1. Back off the table gib by turning the gib adjusting screw counter-clockwise two or three turns. Table gib located at left front of saddle-table dovetail.
2. Remove the cone shaped cover on the right-hand end of the table.
3. Loosen the headless lock screw (Figure 49A) and tap it lightly to free the lock shoe.
4. Tighten the adjusting nut with a face spanner wrench, and then back away about 1⁄16 turn or less.
5. Tighten the lock screw and replace the cover.
6. Turn the table traverse handwheel with the power feed disengaged and try to determine by "feel" whether the bearings have been adjusted correctly. They should not be adjusted so tightly as to make it difficult to move the table, but on the other hand, there should not be a noticeable amount of play in the bearing.
7. Re-adjust the gib.

When the "play" is caused by a worn lead screw and nut, it is necessary to replace these parts in order to obtain accurate work.

Adjusting the Cross Screw Bearings. The cross screw bearings consist of two adjustable tapered roller bearings in the knee. To adjust these bearings, proceed as follows:

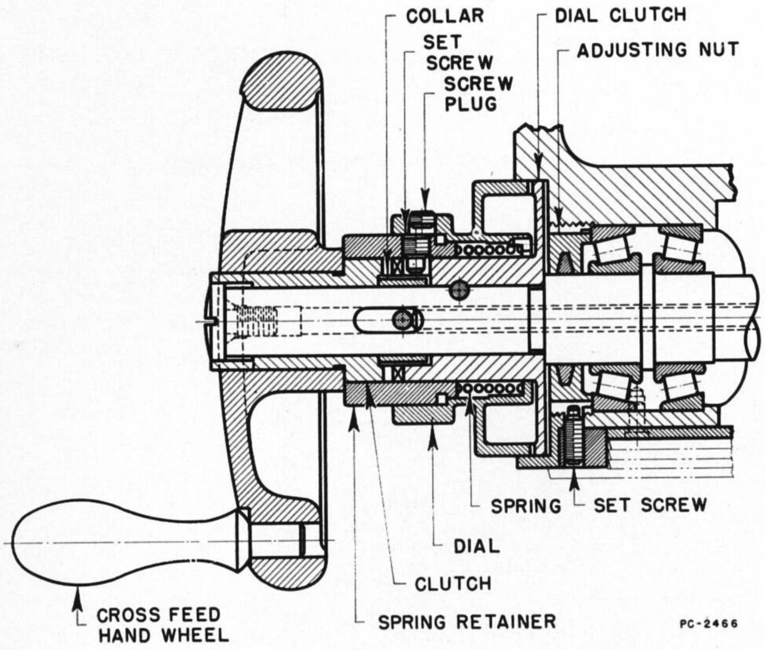


Figure 50A
Section Through Handwheel and Front Bearing of Cross Screw

1. Back off the saddle gib by turning the gib adjusting screw counter-clockwise two or three turns. Saddle gib located on right-hand side of saddle-knee dovetail.
2. Remove the screw in the end of the cross feed screw, and remove the cross feed handwheel (Figure 50A).
3. Remove the screw plug through the diameter of the cross feed dial.
4. Turn the dial until a set screw is visible through the pipe plug hole. Remove this screw.
5. Slip the dial, spring retainer, and spring off the clutch.
6. Knock out the taper pin through the clutch, remove the collar screw from the oblong slot, and remove the clutch and collar.
7. The adjusting nut is now visible. However, before it can be adjusted, one dog point locking screw must be removed. This screw will be found in the knee casting near the dial.
8. Turn the bearing nut clockwise until tight, and then back away one slot.
9. Replace the parts in the reverse order in which they were removed.

Turn the cross feed handwheel with the power feed disengaged and try to determine by the "feel" whether the bearings have been adjusted correctly, as explained under "Adjusting the Lead Screw Bearings", item No. 6.

Adjusting for Stretch and Slip of V-Belts. If the V-belts slip due to stretch or wear, they can be tightened in the following manner:

1. Open the motor compartment door.
2. Loosen four bolts "A" (Figure 51A) and allow the motor to settle in position from its own weight.
3. Re-tighten the bolts and close the motor compartment door.
4. A few words on the care of V-belts: Keep oil and grease away from them. Never apply belt dressing. Be sure pulleys are in line. A cross adjustment is provided for this purpose.

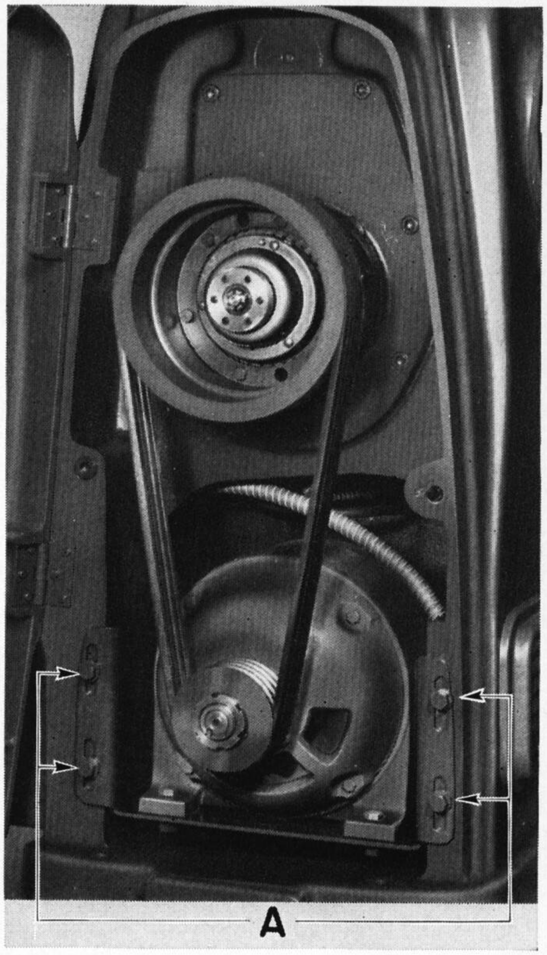


Figure 51A
Location of Bolts "A" for Adjusting the Motor for Stretch and Slip of V-Belts

Adjusting the Spindle Bearings.

1. Move the spindle reverse lever to the middle or neutral position.
2. Remove the two driving keys in the face of the spindle, and clamp a rod, about 10″ or 12″ long, in the key slot.
3. Horizontal Machines—Move the overarm toward the front of the machine, until a small rectangular plate is visible in the top of the column. Remove this plate. The overarm should be moved with the pilot wheel and then pulled out by hand. Make sure that the overarm is supported on its free end.

   Vertical Machines—Remove the pipe plug on the left-hand side of the vertical head, just below the back gear lever.
4. Insert a long Allen wrench through reducing bushing "A" and loosen the socket head screw in the adjusting nut (Figure 52A). Then tap the wrench to loosen the shoe under the screw.
5. With the wrench in position, turn the spindle counter-clockwise about a revolution and then clockwise until the bearings are drawn up tight.
6. Re-tighten the socket head screw and remove the wrench.
7. Now rotate the spindle several times by hand to properly seat the bearings and to be sure that they are adjusted correctly.
8. Replace the cover or pipe plug, move the overarm to its former position, and remove the rod from the face of the spindle.

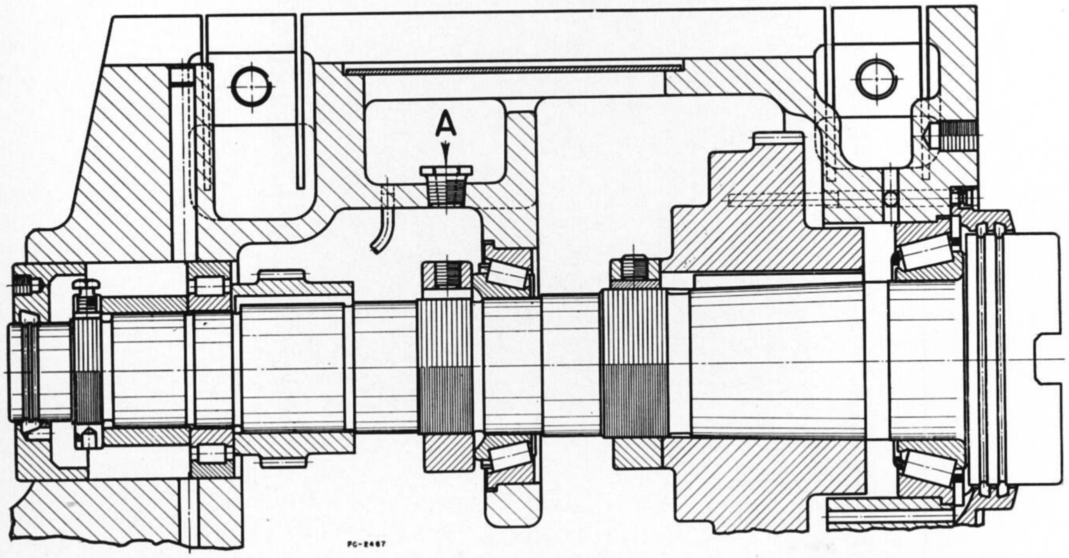


Figure 52A
Section Through Spindle

Machines which are used for general purpose work should have about .001″ end play in the spindle bearings. Machines for high speed work exclusively should have about .002″ end play in the spindle bearings. These readings must be taken with the bearings cold. End play can be measured by indicating the end of the spindle nose with a $\frac{1}{10000}$ indicator and lightly tapping the spindle from the front to the rear and reading the indicator dial. The temperature of the spindle, when run at its highest speed, should not exceed 115° F. when properly adjusted. Test the temperature with a thermometer inserted into one of the screw holes in the spindle cap.

SAFETY PRECAUTIONS

Safety stop dogs are provided for all sliding units. Do not remove these dogs in an effort to obtain more travel, as serious damage to the machine may result. If the job requires a greater range than the safety dogs allow, it must be milled on a machine with greater table travel.

Do not start the machine until all of the oiling stations have been filled with the proper amount of correct lubricants, as shown in the specifications, pages 22 and 25. Follow the instructions on the large tag (Figure 23B) attached to the machine.

The electrical compartment door should never be opened except by an experienced maintenance man for electrical control repair work.

If the spindle speed decreases when the table starts to feed the work into the cutter, possibly the motor is at fault. Have the motor inspected and repaired, if necessary, by an experienced repair man. To avoid possible damage to the motor, make this correction as soon as you notice the spindle speed decreasing under load. The rapid traverse clutch is under spring tension and needs no adjustments.

The clutch on the table hand crank is provided with a spring to keep it out of engagement while it is not in use. Do not remove this spring for the sake of keeping the crank in engagement, as it may result in serious injury to yourself or some other operator.

Do not try to reverse the direction of rotation of the spindle while it is in motion.

The feed change lever should not be moved unless all feed levers are in their neutral positions.

RECOMMENDED CUTTING FLUID

Cimcool Cutting Fluids are manufactured by the Products Division of The Cincinnati Milling Machine Company. Cimcool Cutting Fluids are recommended because of their outstanding advantages in reducing heat at the tool point, freedom of rancidity, cleanliness, freedom from rust, and absence of vapors, hot chips, and slippery floors.

Cimcool S-2, Cimperial and Cimplus are blended with water in varying dilutions depending upon the characteristics of the job. The table below lists the starting dilutions to use when milling various materials.

RECOMMENDED CIMCOOL MIXES

Material	Average Milling Cutters	Form and Low Clearance Cutters
Cast Iron (See Note 1)	CIMPLUS 1:100 CIMCOOL S-2 1:40 CIMPERIAL 1:40	CIMCOOL S-2 1:25 CIMPERIAL 1:40
Mild Steel, Malleable Iron, Wrought Iron, Bronze	CIMCOOL S-2 1:40 CIMPERIAL 1:40	CIMCOOL S-2 1:25 CIMPERIAL 1:30
Brass, Soft Bronze, Aluminum, (See Note 2)	CIMCOOL S-2 1:40	CIMCOOL S-2 1:25
Cast Steel, Tool Steel, and other high tensil strength steels	CIMCOOL S-2 1:25 CIMPERIAL 1:40	CIMCOOL S-2 1:20 CIMPERIAL 1:20

Note 1.—Ordinarily cast iron may be milled dry. If the cutter is small and the cut relatively deep, as when T-slotting or rounding out key ways, an air blast from the compressed air line will keep the cutter sufficiently cool and will also clear out the chips. If the part deforms from heat of machining or is too hot to handle, or greater cleanliness and better dust control is desired, use Cimplus or Cimcool S-2, the latter being used where greater lubricity is required.

Note 2.—Brass, soft bronze and aluminum are normally milled dry. If the part deforms from the heat of machining or is too hot to handle, use CIMCOOL S-2.

CIMCOOL may also be used with carbide tipped cutters; however, a large quantity of fluid should be supplied to insure uniform cooling and to avoid cracking the carbide tips.

General Instructions. Never mix CIMCOOL Cutting Fluids with other cutting fluids. Clean cutting fluid system and tank thoroughly with CIMCOOL machine cleaner before using.

Always add a pre-mixture of the CIMCOOL Concentrate, and water when replenishing the cutting fluid supply.

When making a CIMCOOL mixture, if Cimplus is to be added, add the water first, then CIMCOOL S-2. Never should CIMCOOL S-2 and Cimplus be mixed together in this concentrated form.

CLEANING THE CUTTING FLUID RESERVOIR AND CUTTING FLUID STRAINER

The cutting fluid reservoir in the base of the machine should be cleaned out occasionally to maintain the full capacity for cutting fluid. After pumping out the cutting fluid, remove the cover over the cleanout opening at the rear of the base. With the aid of a small scraper, similar to the soot scraper for the old-fashioned coal range, scrape out the sludge (Figure 56B). Replace the cover.

The cutting fluid strainer and strainer cover should be cleaned at the same time. Lift out the strainer cover and remove the screen from the strainer frame (held by four screws, Figure 56A). Then lift out the cutting fluid strainer. Clean the strainer and screen by washing in solvent and then blowing them off with an air hose. Replace the strainer and strainer cover.

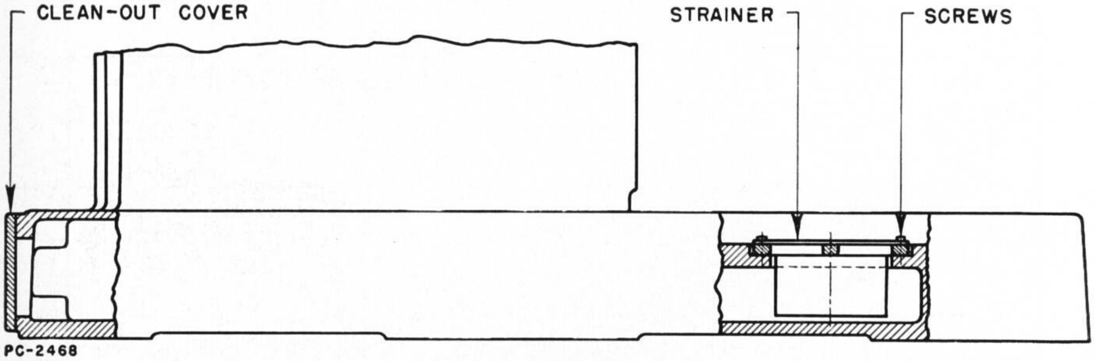


Figure 56A
Strainer and Cleanout Opening in Base

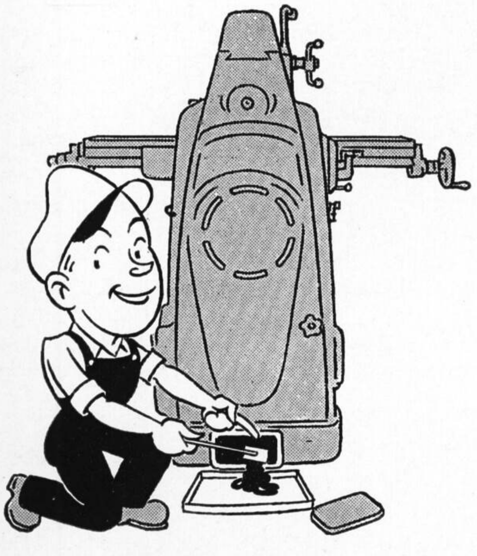


Figure 56B
Scraping Out the Sludge

To insure cleanliness of the reservoir and cutting fluid lines, and to avoid the conditions which lead to rancid cutting fluids, use CIMCOOL machine cleaner. It will remove both grit and dirt, and slime and oil. Use one gallon of CIMCOOL machine cleaner to 25 gallons of hot water, circulate for a half hour, and rinse with clean hot water for three minutes. Then recharge with a fresh CIMCOOL mixture.

DIVIDING HEAD

Cincinnati Dividing and Spiral Milling Heads are used extensively in milling spiral and helical gears, constant velocity drum cams, etc. The manner of transmitting motion to the spindle in the head is the same for both types, but the construction of the main castings are entirely different. The Dividing Head is designed so that its spindle can be swiveled vertically, while the spindle of the Spiral Milling Head is rigidly fixed in a one-piece housing to provide an attachment suitable for heavy and continuous helical milling. The same type of Driving Mechanism is used for both types of heads; therefore the tables and instructions in this booklet apply to both.

The spindle of the dividing head is housed in a swivel block, allowing it to be swiveled to any angle from 5° below the horizontal to 5° beyond the vertical. This arrangement permits bevel gears of any pitch angle to be milled, and many other types of work requiring concentrically spaced slots or holes at an angle to the center line of the work piece

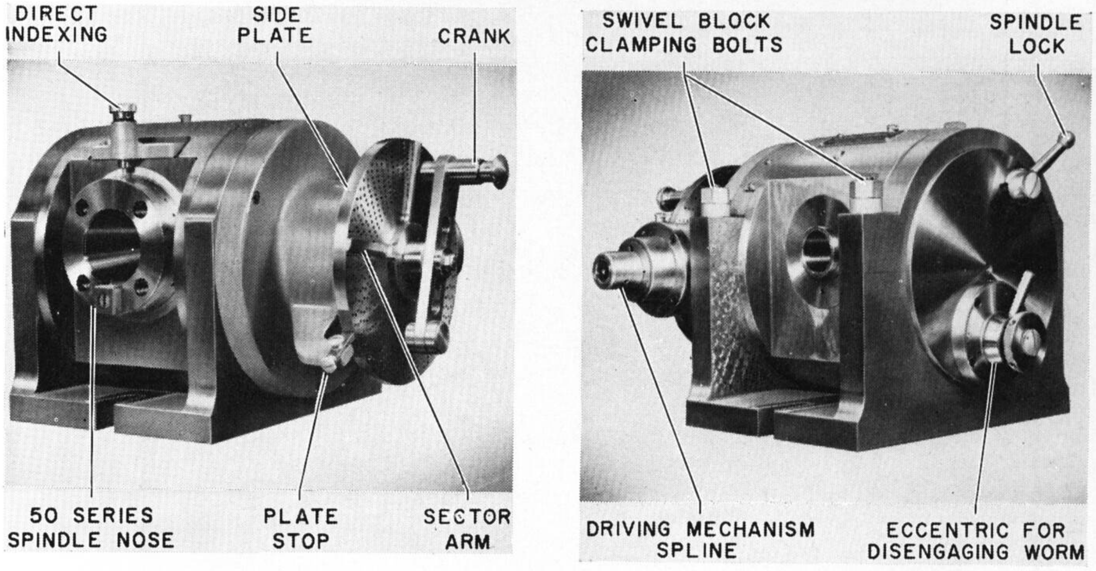


Figure 57A
Front and Rear View of the Dividing Head

The tailstock centers may be swiveled, and also raised or lowered, for taper work. The center-bar is reversible, to bring either the large or the small center point into working position.

Because of the splined shaft drive, the Dividing Head headstock need not be placed flush with the end of the table when set up with the driving mechanism. The 10″ head may be connected to the driving mechanism a maximum of 10½″ from the end of the table. This is the type of set-up required for milling scrolls or certain types of cams.

LUBRICATION OF 8″, 10″, 12″, AND 14″ DIVIDING HEADS

The importance of proper lubrication cannot be over-emphasized. The continued accuracy and long life of the CINCINNATI Dividing Heads depend upon proper lubrication at all times, so do not neglect it.

Follow the instructions and specifications given below.

DIVIDING HEAD

When to Oil	Station Number	Instructions	Parts Lubricated	Specifications
Daily	1	Spring cap oilers, keep filled. Use bench oiler to fill.	Front and rear bearing of mitre gear shaft.	P-55. Good quality paraffinic base oxidation or rust and oxidation inhibited oil.
Daily	2		Worm and worm-wheel, internal gearing, rear bearing of index shaft, front and rear bearing of worm shaft and spindle bearing.	
Daily	3		Bevel gearing and front bearing of index shaft.	

PURCHASE LUBRICATIONS FROM RELIABLE DEALERS

P-55 is The Cincinnati Milling Machine Co. Specification Number.

A list of approved products corresponding to the above specifications may be obtained from our Field Service Department.

Note.—One additional oiler on the Wide Range Dividing Head to lubricate gears in wide range indexing differential unit (Figure 73A).

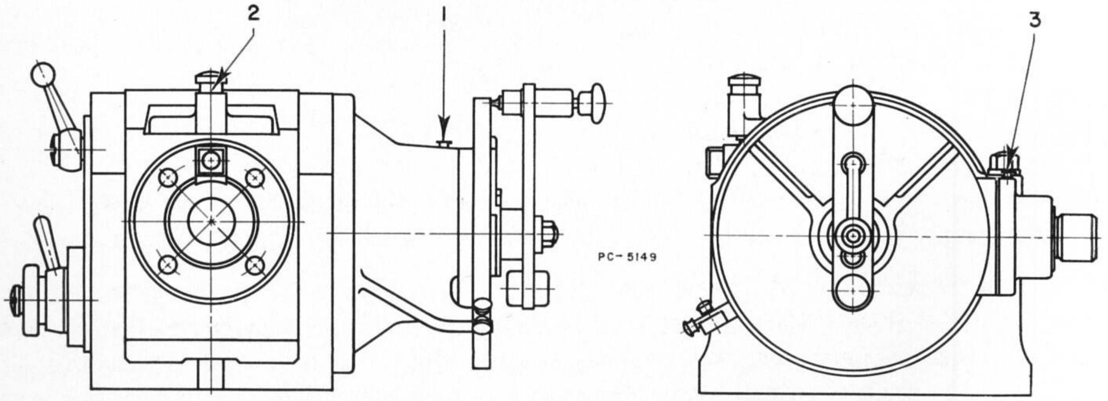


Figure 58A—Lubrication Diagram—Dividing Head

SPECIFICATIONS FOR DIVIDING HEADS

	Size	Actual Swing	Taper Hole in Spindle	Overall Length of Tailstock	Overall Length of Head	Distance from End of Spindle to Table when Spindle is Vertical	Approx. Weight	
							Dividing Head	Tailstock
Dividing Heads.	8″	8½″	40 Series	6½″	10¼″	7½″	130 lbs.	30 lbs.
	10″	10½″	50 Series	6$\frac{13}{16}$″	13″	9$\frac{7}{16}$″	140 lbs.	39 lbs
	12″	12½″	50 Series	7⅛″	15¼″	11$\frac{1}{16}$″	225 lbs.	52 lbs
	14″	14½″	50 Series	7⅛″	15¼″	12$\frac{1}{16}$″	233 lbs.	55 lbs
Ratio..........	40 to 1							
Holes Drilled in Side Index Plate	One side— 24, 25, 28, 30, 34, 37, 38, 39, 41, 42, 43 Other side—46, 47, 49, 51, 53, 54, 57, 58, 59, 62, 66							
Holes Drilled on Spindle Nose	24							

The Sector. Index plates on all CINCINNATI Dividing Heads, Spiral Milling Heads and similar equipment have a sector for convenience in indexing. Fig. 59A shows the sector set for 220 divisions, which requires that, for each division, the index pin move over a series of twelve holes (spaces) in the 66-hole circle. The hole in which the index pointer rests, should not be counted when setting the sector. This factor is sometimes the source of a mistake in setting up dividing head work, and must not be overlooked.

After the sector is spaced for the desired number of holes and tightened with the lock screw, no further counting of holes is necessary. Merely withdraw the index pin from the hole next to the left hand arm of the sector, relocate it in the hole next to the right hand arm, and then swivel the sector to again bring the left hand arm against the pin. The Dividing Head spindle and work will then have rotated 1/220 revolution (for the set-up illustrated).

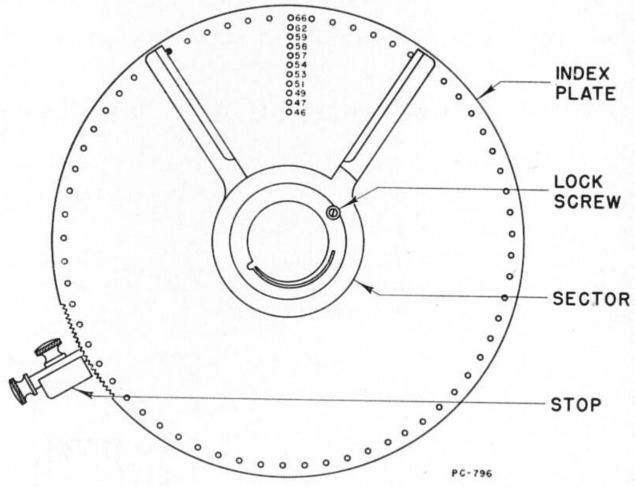


Figure 59A
Dividing Head Sector Set for 220 Divisions

Example: Suppose you want the proper setting for a 21-tooth gear. Consulting the "Index Tables" you will find that for 21 divisions you must use the 42 hole circle. Set the index plate so that the side which has the 42 hole circle faces the index pin. Set the pin in any hole in that circle and space the sector for 38 spaces. Then for each of the 21 divisions, rotate the index pin through one revolution of the crank, plus the spacing of the sector, or 38 spaces.

Index Plate Stop. The index plate stop, Fig. 59A, engages notches in the index plate, preventing it from rotating. If the Head is connected to the driving mechanism for a spiral or helical milling job, the index plate, sector, and crank rotate as a unit. For such a set-up, *the stop must be disengaged from the plate.* In other words, the stop should be engaged only when the Dividing Head is not connected to the power drive, as when milling spur gears, bolt heads, etc. The stop serves as a safety precaution in preventing mistakes which would occur if the index plate itself were moved slightly while indexing.

The index plate stop may also be used as a guide to accurately reset work which has been removed from the Dividing Head for purposes of inspection. First reset the work in approximate relation with the cutter. Then withdraw the index plate stop, and with the index pin engaged, rotate the crank a sufficient amount to accurately position the work. Re-engage the stop in the notches on the rim of the plate. Two inches of the circumference of the plate is notched, and the notches have a pitch of .060″. Therefore, a movement of one notch on the index plate is equivalent to $\frac{1}{18460}$ of a revolution of the work.

Setting Up the Dividing Head to Mill Helices. The instructions given below should be followed in the order in which they are listed.

1. Clean the table of the milling machine and the bottom of the dividing head and tailstock.
2. Clamp the dividing head in the center slot of the table in a location suitable for the work. The 10″ head may be connected a maximum of 10½″ from the right-hand end of the table.
3. Test the dividing head spindle with a test bar and indicator to see that it is parallel with the table.
4. Remove the test bar, and insert the headstock center in the spindle. The center is fitted with a dog holder for driving the work.
5. Place the tailstock on the table, and align its center with the headstock center. For accurate work this adjustment should also be tested with an indicator gage, as in step No. 3, placing the test bar or mandrel between the headstock and tailstock centers. Notice that the tailstock center-bar can be removed and reversed for the purpose of using the heavy center-point for heavy work and the light center-point for light work.

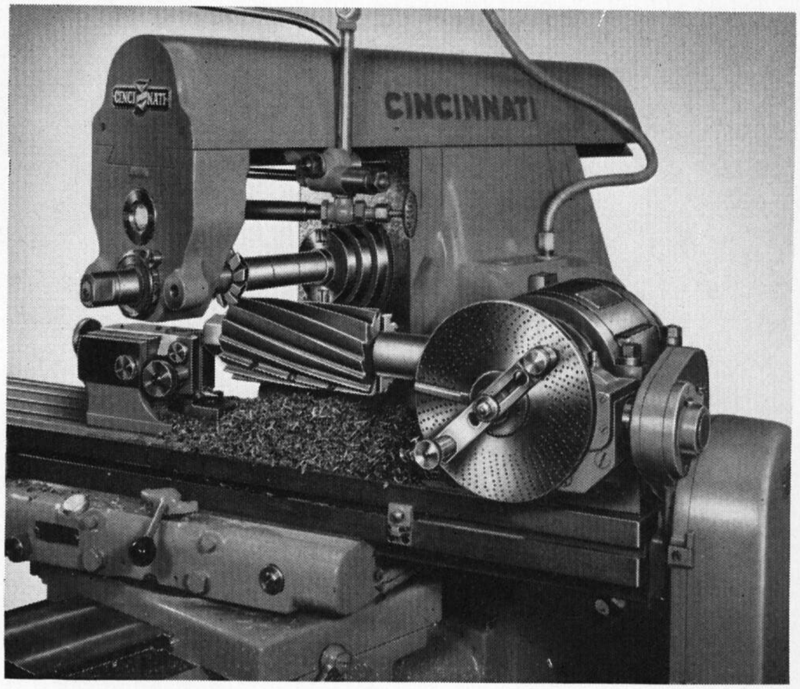


Figure 61A
Dividing Head Set-Up for Milling Helical Cutters on a Universal Milling Machine

6. Clamp the tailstock in the proper position, depending upon the length of the work.

7. (*a*) Mount the cutter, arbor, and arbor support on the machine. The cutter should be placed as close to the machine spindle as practical. If space is available, and a coarse pitch gear is being cut, an intermediate arbor support should be used to give additional stiffness to the arbor.

   (*b*) If the helix angle of the gear is greater than 45°, it will be necessary to use the Spiral Milling Attachment. Mount the cutter next to the back collar. (Figure 62B).

8. Now align the center of the cutter with the Dividing Head centers. This may be done in several ways, and the choice of the method depends upon the accuracy required and the type of set-up.

   (*a*) One of the simplest methods is to touch up the side of the cutter (using feeler .001″ thick) with the outside diameter of a small diameter test bar placed between the Dividing Head centers. Set the cross feed dial to zero. Then adjust the cross traverse one-half the sum of the thickness of the cutter and the diameter of the bar, plus .001″; $\frac{D + T}{2} + .001$. The center of the cutter will then be exactly over the center of the work when the work is placed between centers.

(*b*) If a Spiral Milling Attachment will be used, a gage is supplied for centering the cutter. (See Fig. 62B). Before proceeding farther, swivel the lower part of the attachment (the spindle housing) to the same angle as the helix angle of the gear teeth. Then loosen thumb screw "A" and center the cutter with the gage (Fig. 62B). Now loosen thumb screw "B" and adjust the centering gage downward about one inch. Elevate the knee and adjust the cross movement to match the point of the centering gage with the point of the headstock or tailstock center. This can be done very accurately by eye.

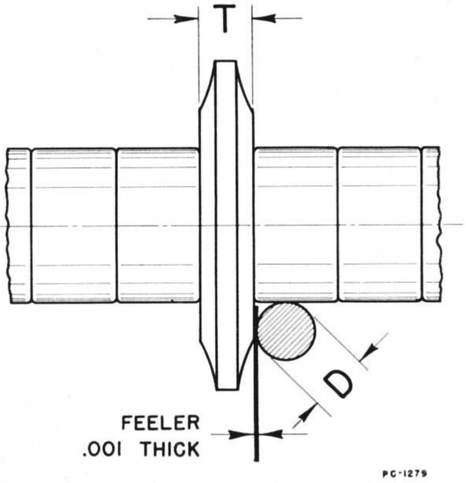


Figure 62A
Conventional Set-Up. Aligning Center of Cutter with Center of Work

9. Lock the machine saddle to the knee.

10. Swing the table to the correct angle, (universal machine only—see step 8b for set-ups using spiral milling attachment); and lock the machine housing in position.

11. Withdraw the index plate stop. (Fig. 59A). The index plate must be free to revolve with the index pin. *Note*—Engage the stop with the notches in the rim of the plate only when using the Dividing Head without the driving mechanism.

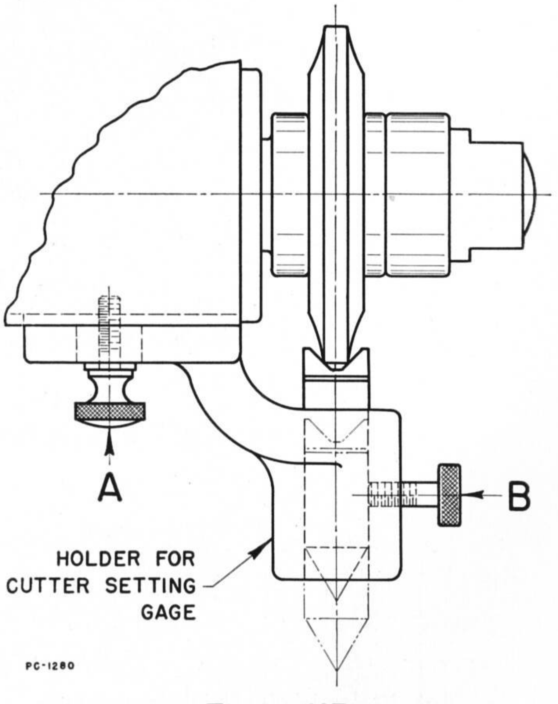


Figure 62B
Attachment Set-Up. Aligning Center of Cutter with Center of Work

12. Set up the change gears. (See page 64.)

13. Set the index plate and sector for the proper spacing. (See Fig. 59A).

14. Oil the dividing head and change gears thoroughly.

15. *Note*—If the Dividing Head is equipped with a Wide Range Divider, (page 71) we do not recommend the use of the power rapid traverse to the table. It is also advisable not to use the table rapid traverse when the change gears are set up for leads less than 5″.

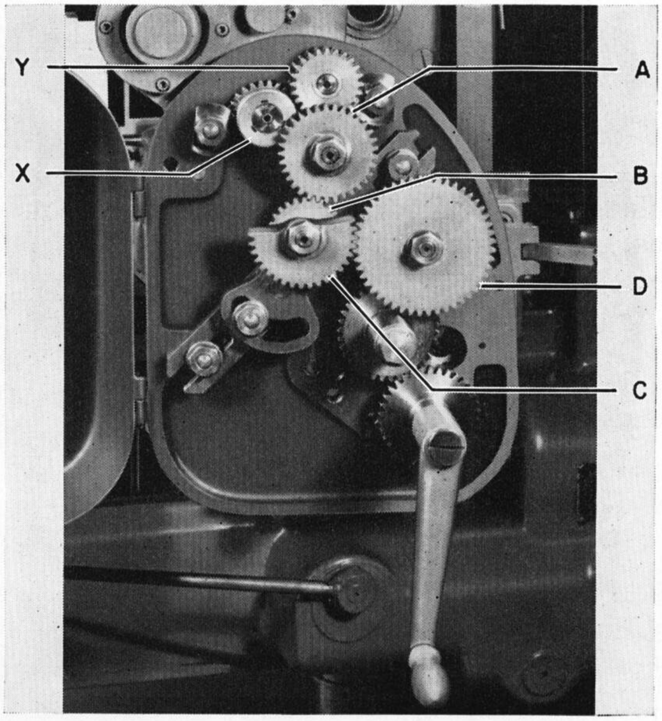


Figure 63A
Standard Dividing Head Driving Mechanism

How to Select the Proper Change Gears. Suppose you want to cut a helix of 15¼″ lead. Consult the "Table of Leads" and find the lead which is nearest 15¼—in this case 15.256. The change gears for this lead, 51, 18, 21, and 39, may be used, because the lead obtained is close enough to the lead desired for practical purposes.

You will notice that gear "C" is not listed for some leads. In such cases only one intermediate gear "B" is required, and a collar replaces gear "C".

Setting Up the Change Gears. Remove the conical shaped cover on the apron at the right-hand end of the table. It is held in position with a small headless set screw. Then place the change gear segment on the apron, screw half-nuts on the two studs, and tighten them securely. Place the change gears in the positions indicated for the desired lead, being careful not to get gears "B" and "C" interchanged. The "hand" of the lead is fixed by gears "X" and "Y", as shown in the table below

After the set-up has been completed, move the table by means of the hand feed crank, to be sure that the entire mechanism operates freely, before engaging the power feed. Remove the hand crank and keep the cover closed while the machine is in operation.

	Right-Hand Helix	**Left-Hand Helix**
Dividing Head	Remove gear Y Reverse gear X	Gears X and Y, as shown in Fig 63A
12″ Spiral Head	Gears X and Y, as shown in Fig. 63A	Remove gear Y Reverse gear X

Leads Lower than Those Listed in Tables. With the standard driving mechanism illustrated in Fig. 63A, leads lower than those listed in the tables, pages 102-118, can be obtained, *using hand feed only* (rotating the index crank at the side of the head). To change the gearing for low leads, remove gear "D". A 34 tooth gear is now exposed, meshing with the 34 tooth gear on the lead screw (directly below gear "D"). Remove these two 34 tooth gears, and replace them with the standard 51 tooth change gear on the lead screw and the standard 17 tooth change gear on the stud for gear "D". Instead of a 1 to 1 ratio, we now have a speed-up of 3 to 1. Leads for the change gear combinations listed are now divided by 3. However, some of the change gear combinations are not obtainable because of interference with the segment.

This set-up should be used only for occasional jobs. If leads shorter than 2½″ are cut often, we recommend the short lead bracket. With this additional equipment, the range of leads is increased to ⅛″ to 100″. It should be installed at our factory. Complete instructions for this type of equipment is contained in a separate booklet "Table of Leads—⅛″ to 100″ Lead Driving Mechanism".

Leads Near the Low Range. When cutting leads within the low range of the Dividing Head driving mechanism, certain precautions must be observed. If, for example, the gears are set up for a 10″ lead, the ratio of the change gears is 1 to 1, and the table feed (lead) screw rotates 40 revolutions to one revolution of the dividing head spindle.

For leads greater than 10″, the dividing head spindle runs slower in relation to the speed of the lead screw. Example: 20″ lead, table feed screw rotates 80 revolutions, while the dividing head spindle rotates one revolution. This requires a change gear set-up which reduces the speed from the lead screw to the dividing head, resulting in a mechanical advantage in transmitting power.

For leads shorter than 10″, the dividing head spindle runs faster in relation to the speed of the lead screw. Example: 5″ lead, table feed screw rotates 20 revolutions, while the dividing head spindle rotates one revolution. The change gear set-up for these low leads increases the speed from the lead screw to the dividing head, resulting in a mechanical disadvantage in transmitting power. The slow speed of the lead screw causes a "wind-up", which may produce a slightly jerky motion when milling short leads on large diameters of work. Therefore, conditions should be as nearly correct as possible when cutting short leads, particularly those from 2½″ to 5″. These conditions may be summarized in a few words. (*a*) the table gib should be correctly adjusted (not too tight), (*b*) the change gears should have a slight amount of back-lash, (*c*) the table ways and lead screw should be well oiled, (*d*) the table feed screw should rotate freely. Also, it might be noted that with a relatively high table feed, say 5¾″ per minute, a greater proportion of power is available at the dividing head.

When all contributing factors are correct, the machine will pull a reasonable cut with a set-up for the lowest lead of 2½″. If the cut should be unnecessarily heavy, then it is advisable to feed by hand. This may be done by allowing the table feed engaging lever to remain in neutral position and driving the dividing head and table by hand through the index crank in front of the index plate. With a short lead set-up hand feed is very easy, as the mechanical advantage is then in favor of the operator.

If leads lower than 5″ must be cut often, we recommend our short lead mechanism. (It may be applied to Universal machines only.) Then leads as low as ¼″ may be cut by power.

Rapid Traverse and High Feed Rates. *Plain Bearings.* When the driving mechanism is set up for low leads, *do not* engage the table rapid traverse, or use high feed rates. Rapid rates of table traverse drive the dividing head too fast, resulting in rapid wear or perhaps "freezing" of the dividing head spindle in the block, as they are fitted very closely to obtain accuracy in spacing.

Ball Bearings. When using the driving mechanism, reverse the table only when the feed is engaged. Do not reverse it while the rapid traverse is engaged, as entirely too much strain is setup in the mechanism of the machine and attachment. For example, after milling a spiral groove, reverse the table while in feed then engage the rapid traverse to get back to the starting position.

Calculating the Change Gears Required for a Given Lead. Many leads can be obtained other than those listed in the table. They were omitted because the difference was too small for ordinary requirements, but if you do not find a lead in the table which is close enough to meet your needs, the following formula will enable you to calculate all the possibilities:

$$\frac{\text{Lead}}{10} = \frac{\text{Driven}}{\text{Drivers}} = \frac{A \times C}{B \times D}$$

Suppose you want a lead of 35.789″,

$$\frac{35.789}{10} = 3.5789, \qquad \frac{51 \times 36}{27 \times 19} = 3.579$$

Gear A = 51 Teeth
Gear B = 27 Teeth
Gear C = 36 Teeth
Gear D = 19 Teeth

Standard change gears furnished with enclosed driving mechanism:

1 — 17 teeth
1 — 18 teeth
1 — 19 teeth
1 — 20 teeth
1 — 21 teeth
1 — 22 teeth
2 — 24 teeth
1 — 27 teeth
1 — 30 teeth
1 — 33 teeth
1 — 36 teeth
1 — 39 teeth
1 — 42 teeth
1 — 45 teeth
1 — 48 teeth
1 — 51 teeth
1 — 55 teeth
1 — 60 teeth

A few gear combinations can not be used because of interferences (and consequently are not tabulated.) For example, lead 36.090, gears 48-19-30-21.

How to Calculate the Angle for Setting the Milling Machine Table or Spiral Milling Attachment. Suppose you want to mill a lead of 7½″ on a 3″ diameter *work piece. The angle for swiveling the table is not shown for this combination, but it can be calculated very easily from the following formula:

$$\text{Tangent of angle} = \frac{3.1416 \times \text{diameter}}{\text{lead}}$$

$$\text{In the above example, Tan. angle} = \frac{3.1416 \times 3}{7.5} = 1.2566$$

Angle = 51½° (See table, page 119.)

***Note:** Use pitch diameter in calculating helix angle for helical and spiral gears, worms, etc.

How to Calculate Indexing with the Side Plate. (Standard Dividing Head). In case a particular circle of holes on the index plate becomes worn through constant use, you may be able to use some other circle of holes and get the same result.

The following set of rules and example illustrate the procedure to follow in obtaining the maximum number of settings for any condition of indexing. Since the ratio between the worm and worm-wheel in the Cincinnati Dividing Head is 40 to 1, then:

1. Divide 40 by the number of divisions required. The result gives the number of turns or fraction of a turn of the index crank.
2. If a fraction of a turn is required, the denominator (the lower part of the fraction) represents the circle to use, while the numerator represents the number of spaces in the circle over which the index pin must pass.
3. Reduce the fraction to its lowest terms, and multiply both parts of the fraction by the same number until the denominator equals the number of holes in any circle.

Example

Suppose you want to calculate all the indexing circles for 3 divisions.

$\frac{40}{3} = 13\frac{1}{3}$ turns of the index crank.

One-third of a turn could be obtained by rotating the index pin over one space in a 3 division circle—(Rule 2). Since we do not have a 3 hole circle, we must use one into which the number of holes can be evenly divided by 3. For instance, 8 spaces in the 24 hole circle (8/24 = 1/3), 10 spaces in the 30 hole circle (10/30 = 1/3), etc. One-third of a turn can be obtained in any of the following circles:

$\frac{1 \times 8}{3 \times 8} = \frac{8}{24}$ or 8 spaces in the 24 hole circle.
$\frac{1 \times 10}{3 \times 10} = \frac{10}{30}$ “ 10 “ “ “ 30 “ “
$\frac{1 \times 13}{3 \times 13} = \frac{13}{39}$ “ 13 “ “ “ 39 “ “
$\frac{1 \times 14}{3 \times 14} = \frac{14}{42}$ “ 14 “ “ “ 42 “ “
$\frac{1 \times 17}{3 \times 17} = \frac{17}{51}$ “ 17 “ “ “ 51 “ “
$\frac{1 \times 18}{3 \times 18} = \frac{18}{54}$ “ 18 “ “ “ 54 “ “
$\frac{1 \times 19}{3 \times 19} = \frac{19}{57}$ “ 19 “ “ “ 57 “ “
$\frac{1 \times 22}{3 \times 22} = \frac{22}{66}$ “ 22 “ “ “ 66 “ “

Example

Suppose you want to calculate all the indexing circles for 56 divisions.

$\frac{40}{56} = \frac{5}{7}$ of a turn of the index crank.

$\frac{5 \times 4}{7 \times 4} = \frac{20}{28}$ or 20 spaces in the 28 hole circle.

$\frac{5 \times 6}{7 \times 6} = \frac{30}{42}$ " 30 " " " 42 " "

$\frac{5 \times 7}{7 \times 7} = \frac{35}{49}$ " 35 " " " 49 " "

Angular Indexing. Tables for angular indexing with the standard and high number index plates are not tabulated in this book because they are little used as compared to numerical divisions. However, angular spacing can readily be calculated, keeping in mind that one complete turn of the index crank = 9°, one space in the 30 hole circle = 18′, and one space in the 54 hole circle = 10′. The tabulation at the right shows the angular movement of the Dividing Head spindle for a movement of the index crank of one space in the various hole circles

Circle	One Space	Circle	One Space
24	22′ 30″	46	11′ 44″
25	21′ 36″	47	11′ 29″
28	19′ 17″	49	11′ 1″
30	18′ 0″	51	10′ 35″
34	15′ 53″	53	10′ 11″
37	14′ 36″	54	10′ 0″
38	14′ 13″	57	9′ 28″
39	13′ 51″	58	9′ 19″
41	13′ 10″	59	9′ 9″
42	12′ 51″	62	8′ 43″
43	12′ 33″	66	8′ 11″

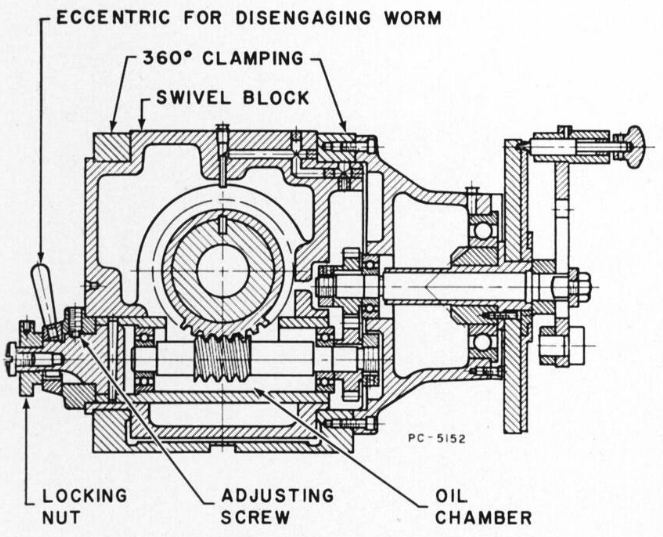


Figure 68A
Section Through Dividing Head Showing Worm

Direct Indexing from the Spindle Nose. Direct indexing is often used for making the divisions listed in the table on page 69 because it is faster than indexing with the side plate through the 40 to 1 worm reduction. To change the dividing head into plain index centers, turn the eccentric for disengaging the worm (Fig. 68A) through half a turn. The worm is then disengaged and indexing is accomplished by turning the spindle by hand.

The spindle nose (Figure 69A) is drilled with a 24 hole circle. It will index any number which divides evenly into this 24 hole circle. When changing from plain indexing back to universal indexing through the side plate, it is important that the front index pin be locked in its "up" position.

Direct Indexing from the Spindle Nose

Divisions	Spaces
2	12
3	8
4	6
6	4
8	3
12	2
24	1

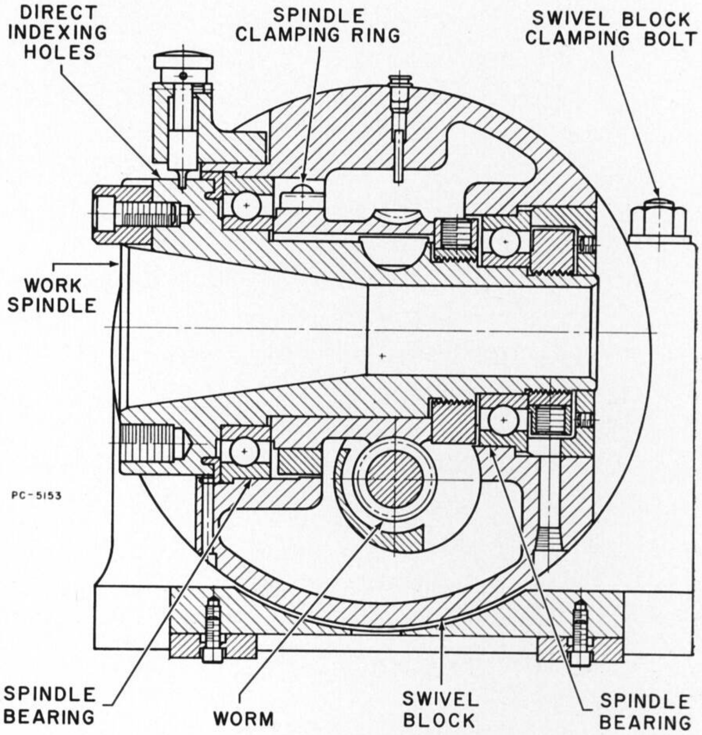


Figure 69A
Section Through Dividing Head Showing Spindle Nose

Clamping the Dividing Head Spindle in Place. The spindle should be clamped tightly (except when milling spirals) during heavy cutting operations to relieve all strains on the worm, worm-wheel, and index pin. (Figure 69B). Lever "A" (Figure 65B) closes 360° clamping ring "B" firmly clamping the spindle in place. Be sure to unclamp the spindle before turning the index crank or engaging the table feed while the head is set up for milling spirals.

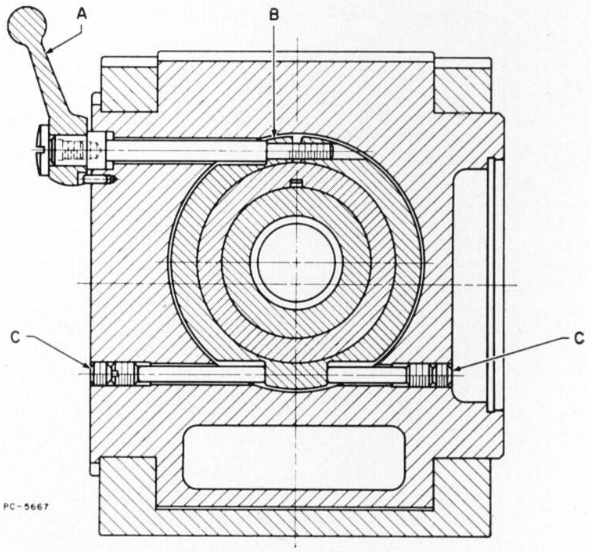


Figure 69B
Section Through Dividing Head Showing Spindle Clamp

Adjusting the Dividing Head Worm. Wear between the worm and worm-wheel may be eliminated in the following manner:

1. Loosen knurled locknut (Figure 70A) and *engage worm and worm-wheel by positioning lever in the extreme left position (as shown in Figure 70A). This must be done when backlash adjustment is to be made.
2. Remove the backlash from the work by tightening knurled locknut on end of the worm shaft.
3. Remove set screw "A" and loosen dog-point screw "B" (Figure 70A).
4. Loosen knurled locknut and move disengage lever slightly more to the left position.
5. Tighten knurled locknut and rotate dividing head spindle by hand to see if it rotates freely with no evidence of backlash. Tighten set screw "B".
6. Replace set screw "A". Loosening set screw "B" reduces backlash, tightening increases backlash.

*Caution should be taken when engaging worm and worm-wheel. Do so slowly, making sure worm and worm-wheel are meshing, avoiding injury to worm-wheel.

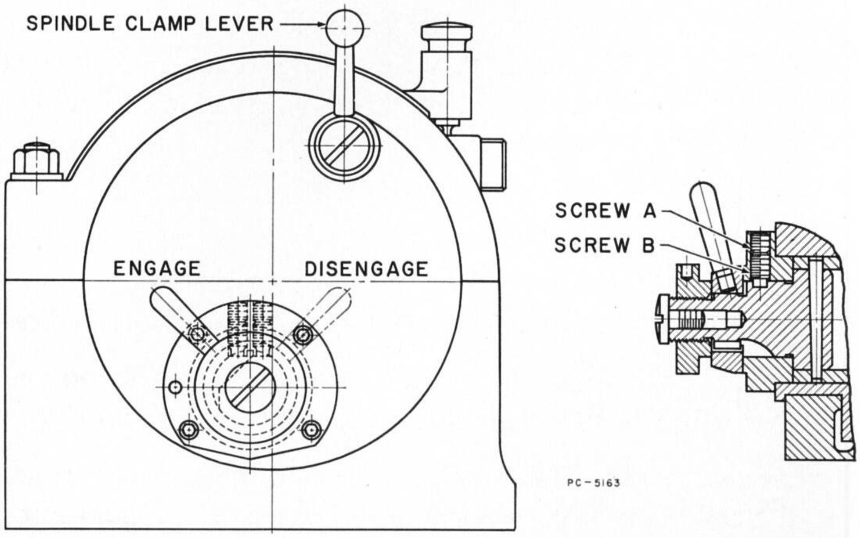


Figure 70A
Section Showing Adjusting Screws

THE WIDE RANGE DIVIDER

The Wide Range Divider applied to a Cincinnati Universal Dividing Head enables you to obtain divisions from 2 up to 400,000. It consists of large index plate "A", sector and crank "B", together with a small index plate "C", and sector and crank "D". The mechanism is so arranged that crank "D" operates through reduction gearing of 100 to 1 ratio enclosed in housing "G". The ratio between the worm shaft and the spindles is 40 to 1.

Set up for indexing in the conventional manner. The divisions given in the table (page 97) can be obtained by utilizing crank "B" only in combination with the proper hole circle on the large plate. (Large plate drilled on both sides and contains 11 circles of holes on each side). The index pin in crank "B" can be swiveled to any hole circle. When indexing in this conventional manner, the operation is exactly the same as it is on the regular Cincinnati Dividing Heads.

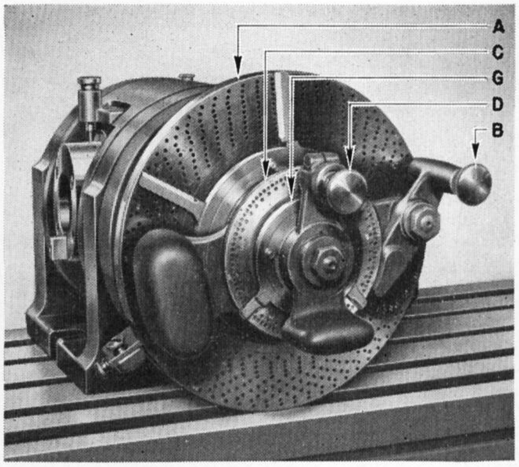


Figure 71A
Wide Range Divider

How to use the Wide Range Divider. Any whole number of divisions, up to and including 60, and hundreds of others, can be obtained with the large plate only, and the setting may be read directly from the table, page 97. If the number of divisions required is not listed in the table, calculate the setting in the following manner:

Set-up

*1. Divide 400,000 by the number of divisions desired, for example 67. The result gives you a whole number quotient and a fraction—$5970\frac{10}{67}$.

2. Set the sector on large index plate "A" for 59 spaces on the 100-hole circle, 59 being the first two whole numbers of the quotient obtained.

3. Set the sector on the small index plate "C" for 70 spaces on the 100-hole circle, 70 being the last two whole numbers of the quotient obtained.

*Note: Should the quotient be a five-digit number, the first number represents the number of full turns of crank "B". (No five-digit quotient appears when making divisions higher than 40, and furthermore, calculations are unnecessary for any number less than 61.)

Operation

4. Index crank "B" an amount equal to the sector setting, namely—59 spaces.
5. Then index crank "D" an amount equal to the sector setting, namely—70 spaces. (Both cranks are moved in the same direction.)
6. Compensate for fraction 10/67 by adding one space to the index movement of the small crank "D" at intervals equal to the nearest whole number obtained by dividing 1 by 10/67. The result of this division is 7. Therefore, every seventh division, index 71 spaces on the small plate "C" instead of 70. In this way one space is lost, but the resulting error is equal to only .0000942″ on a 12″ diameter circle.

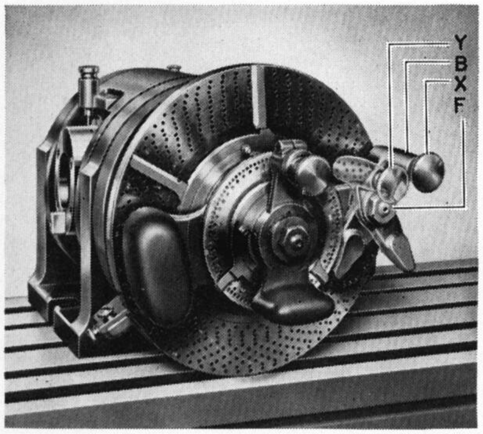


Figure 72A
When indexing in the conventional manner (divisions tabulated on page 97), index crank "B" may be changed to a different circle of holes, as from "X" to "Y", by merely loosening nut "F"

Angular Spaced Divisions. If the divisions are spaced in degrees, minutes, and seconds, the procedure in calculating the setting is very similar to that outlined above, except that for sake of convenience, use the 54-hole circle on both plates. Complete tables are listed on pages 100 and 101.

Using crank B on the large plate (Figure 71A):

(*a*) One complete turn is equivalent to 9 degrees.
(*b*) Six spaces in the 54-hole circle equals 1 degree.
(*c*) One space in the 54-hole circle equals 10 minutes.

Using crank D on the small plate:

(*a*) One complete turn of crank "D" equals 5 minutes and 24 seconds.
(*b*) Ten spaces in 54-hole circle equals 1 minute.
(*c*) One space in 54-hole circle equals 6 seconds.

Example. Indexing an Angle of 3 Degrees, 20 Minutes, 12 Seconds.

Set-up

1. Consulting the "Degree" table on page 100, set the sector on index plate "A" (Fig. 71A) for 18 spaces on the 54-hole circle.
2. Consulting the "Fractions of a Degree" table on page 101, set sector "G" on plate "C" for 40 spaces on the 54-hole circle.

Operation

1. Index large crank "B" (Fig. 71A) an amount equal to the sector setting, namely—18 spaces.
2. Index small crank "D" three turns (see table) plus the sector setting, namely—40 spaces. (Both cranks are moved in the same direction.)

The index pin in the crank for the small plate is eccentric to provide a method of adjusting the pin from the 100-hole to the 54-hole circle, and vice versa. Merely loosen screw "E" (Fig. 73A), rotate the pin to the desired circle of holes, and then retighten the screw.

Reversing the Large Index Plate (Wide Range Divider). If the set-up requires the reversal of the large index plate, the operation may be accomplished in the following manner:

1. Remove nut "A" and the washer behind it. (Fig. 73A).
2. Slip differential unit "B" off the shaft.
3. Sector "C" is now free and may be removed.
4. Remove four screws "D", reverse the plate, and reassemble the parts.

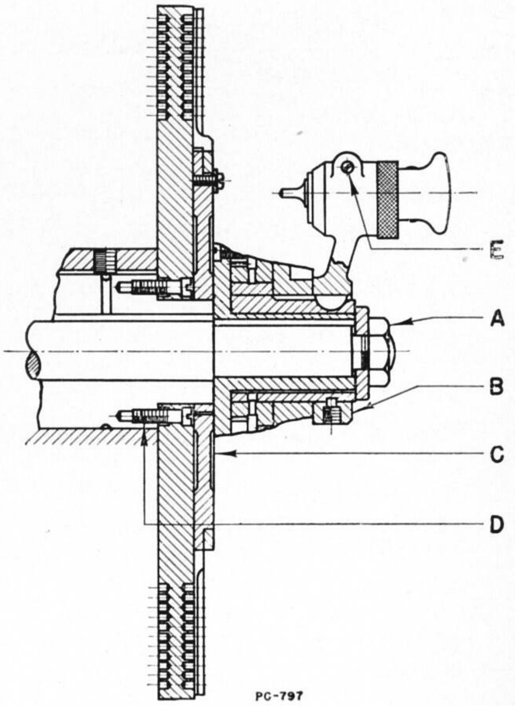


Figure 73A
Section Through Differential Mechanism

MILLING CAMS

Rise and fall cams having a relatively narrow face may be machined by using the type of set-up indicated in Figure 74A. The cutter may be supported in any type of swiveling head such as a Universal Spiral Milling Attachment, Independent Overhead Spindle, or Heavy Vertical Attachment. Almost any cam lead can be machined, and by trying different machine leads, the angle to which the dividing head must be set can be changed to suit conditions. All you need in addition to this instruction book is a table of sine functions

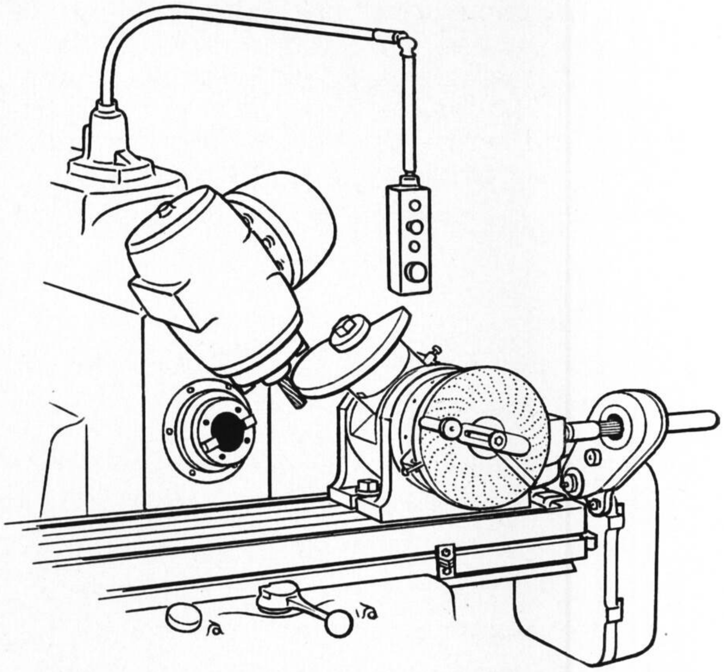


Figure 74A
Diagrammatic Sketch of Dividing Head Set Up for Milling Cams

Formula: $\frac{\text{Lead of Cam}}{\text{Lead of Table}} = \text{Sine of Angle ``D''}.$

Examples:

1. Suppose you want to mill a cam having a .500″ lead. Assume change gears are set up for 2.5″ table lead.

$$\frac{\text{Lead of Cam}}{\text{Lead of Table}} = \frac{.5}{2.5} = .200;\ \text{sine of angle ``D''}.$$

"D" = 11 degrees, 33 min.

2. Suppose you want to mill a lead of 6.005″.

(a) Assume change gears are set up for 8″ table lead.

$$\frac{\text{Lead of Cam}}{\text{Lead of Table}} = \frac{6.005}{8} = .7506;\ \text{Angle ``D''} = 48 \text{ degrees, } 39 \text{ min.}$$

(b) Assume change gears are set up for 9.935″ table lead, instead of 8″, as in example 2a, then

$$\frac{6.005}{9.935} = .6044;\ \text{and Angle ``D''} = 37 \text{ degrees, } 11 \text{ min.}$$

BACKLASH ELIMINATOR

There are two distinct methods of milling: (a) conventional, or up-milling, Figure 75A, and (b) climb, or down-milling, Figure 75B. A combination of these, that is using right and left hand fixtures would be reciprocal milling. The forces created in up-milling tend to lift the part up into the cutter and spring the cutter down into the work. In down milling, the cutter has a tendency to spring away from the work and at the same time, push the work down against its supporting surface. In up-milling, the thickness of the chip increases uniformly from zero at the bottom (beginning) of the cut to a maximum at the top of the cut, while in down-milling, the chip thickness decreases uniformly from a maximum at the top (beginning) of the cut to zero at the bottom (end) of the cut (Figures 75A and 75B). Although the majority of milling operations can be done either way, down-milling produces the better results on thin parts which are difficult to hold; exceptionally wide cuts; or thin deep cuts as when sawing slots.

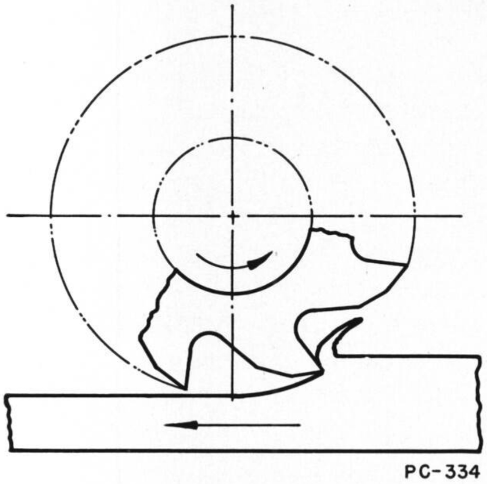


Figure 75A
Conventional, or Up-Milling

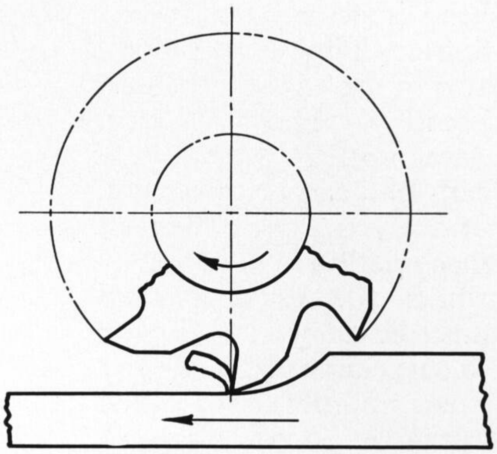


Figure 75B
Climb, or Down-Milling

The backlash eliminator device, shown diagrammatically in Figure 76A, is required for down-milling operations. Supplied as standard equipment on all sizes of machines. It is entirely within the saddle beneath the table, the only indication being knob "G" at the front of the saddle (Figure 77A).

When machines are equipped with a backlash eliminator, either down-milling or up-milling operations can be handled. During up-milling cuts or when rapid traversing, the backlash eliminator is automatically released. However, in down-milling, as soon as the cutter contacts the work, the backlash between the nut and the lead screw is automatically taken up.

The device consists essentially of two nuts, "A" and "B", freely mounted on the table lead screw. The crown teeth on gear "D" mesh with the gear teeth on nuts "A" and "B". Therefore, when one nut rotates, the other nut will also rotate but in the opposite direction. The spur gear teeth on gear "D" mesh with rack "C".

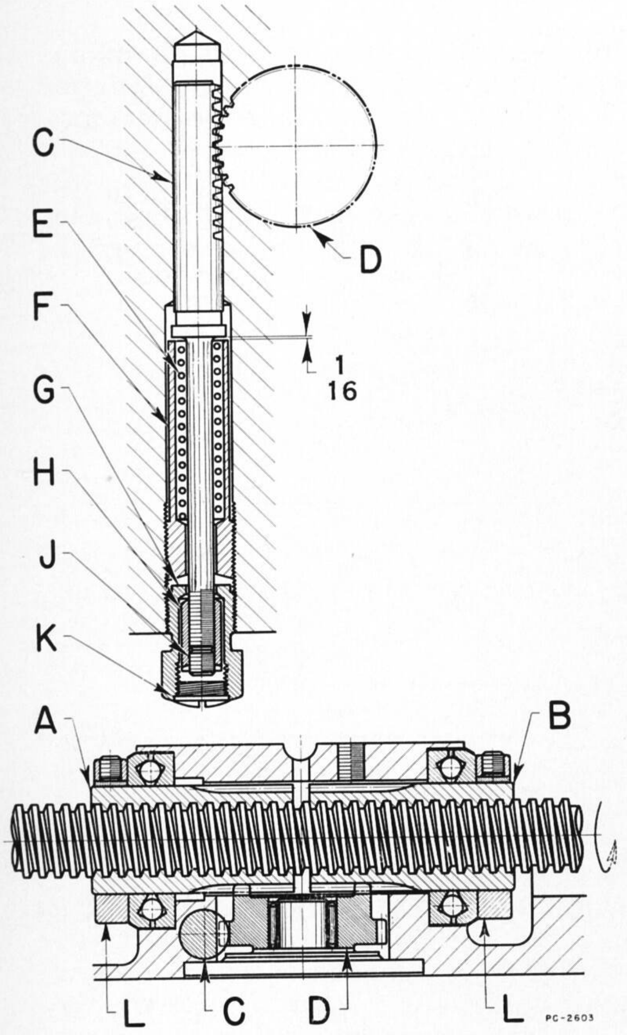


Figure 76A
Diagrammatic Sketch of Backlash Eliminator, Showing Adjustment

Spring "E", contained within sleeve "F", tends to push in rack "C", rotating crown gear "D" and nuts "A" and "B" a sufficient amount to eliminate the backlash. Threaded sleeve "F" serves two purposes: (a) to provide adjustment, and (b) to provide a stop for the outward movement of the rack.

Operation of Backlash Eliminator. Suppose we consider in detail the table movement to the right. Actually, the same discussion may be applied to either direction of travel. When the lead screw (it has a right hand thread) rotates in the direction indicated in the illustration, the table moves to the right.

The resulting thrust and friction on nut "B" causes it to rotate a slight amount in the same direction as the lead screw. Nut "A", through crown gear "D", rotates a fraction of a revolution in the opposite direction. Rack "C" then moves out against sleeve "F" and relieves the spring pressure.

If an up-milling cut is being taken or if the table is rapid traversed to the right, obviously the reaction on nut "B" is the same as explained above, and no change will take place in the position of nuts "A" and "B".

On the other hand, if the cutter is rotating with the feed of the table, as in "Down Milling", as soon as the cutter engages the work, the thrust will shift from nut "B" to nut "A". The frictional torque between nut "A" and the lead screw is thereby increased, and consequently, nuts "A" and "B" will tend to rotate in the direction which will preload the ball bearings. This action immediately eliminates the backlash between the screw and the nut. As soon as the "Down Milling" load is removed, nuts "A" and "B" are brought back to the initial conditions by the thrust of the table which now acts on nut "B".

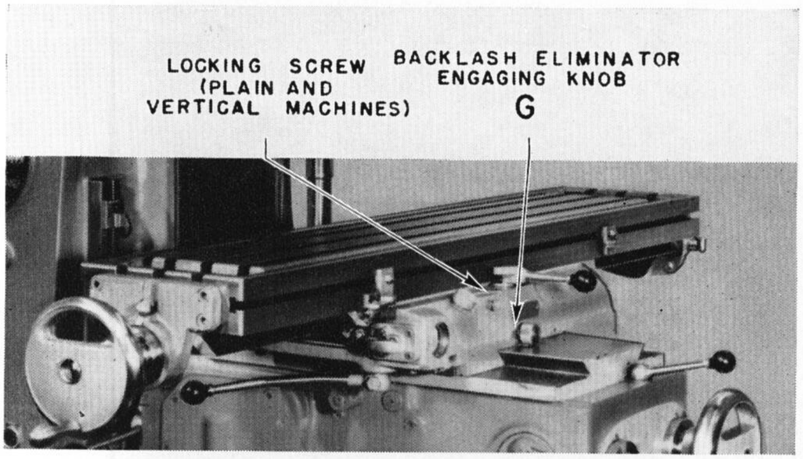

LOCKING SCREW (PLAIN AND VERTICAL MACHINES)
BACKLASH ELIMINATOR ENGAGING KNOB
G

Figure 77A
Front View of Saddle, Showing Backlash Eliminator Engaging Knob. Locking Screw is Also Shown (Plain and Vertical Machines)

Adjusting the Backlash Eliminator. There should be no need to adjust the backlash eliminator unless previously mis-adjusted or dismantled. If necessary to adjust the device, proceed in the following manner, with the machine stopped.

1. Adjust the table lead screw bearings, page 49.
2. Remove screw plug "K", lock screw "J", nut "H", and engaging knob "G" from the front of the saddle.
3. *Plain and Vertical Machines.* Remove headless set screw and loosen locking screw a few turns (for location of screw, see Figure 77A).

   Universal Machines. Loosen locking screw a few turns (for location of screw, see Figure 78A).
4. Push in rack "C" and, while holding it there, adjust sleeve "F" until tight against shoulder of rack, then back it away about ⅓ turn.
5. Tighten the locking screw.
6. Replace the set screw (Plain and Vertical Machines only).
7. Replace engaging knob "G" and screw in until tight and then back off two complete turns.
8. Replace nut "H" and screw in until it touches shoulder of knob "G", then back off nut "H" one turn.
9. Replace headless lock screw "J", holding nut "H" so it cannot move. Tighten screw "J" as tight as possible, so as to lock nut "H" to rack "C".

   When above is completed, you should be able to move knob "G" approximately two complete turns before rack "C" will begin to move out to disengaged backlash position.
10. Replace screw plug "K".

Properly adjusted, rack "C" should move out about $\frac{1}{64}''$ when the table feed or rapid traverse is engaged in either direction. This can be observed by removing screw plug "K" and engaging the table feed and rapid traverse levers.

Engaging and Disengaging the Backlash Eliminator. For down-milling (also up-milling, if desired) turn knurled knob "G" in (clockwise) until tight; to disengage backlash eliminator, turn knurled knob "G" out (counter-clockwise) until tight. If desired, the Backlash Eliminator can be engaged continually, and released only for hand adjustment.

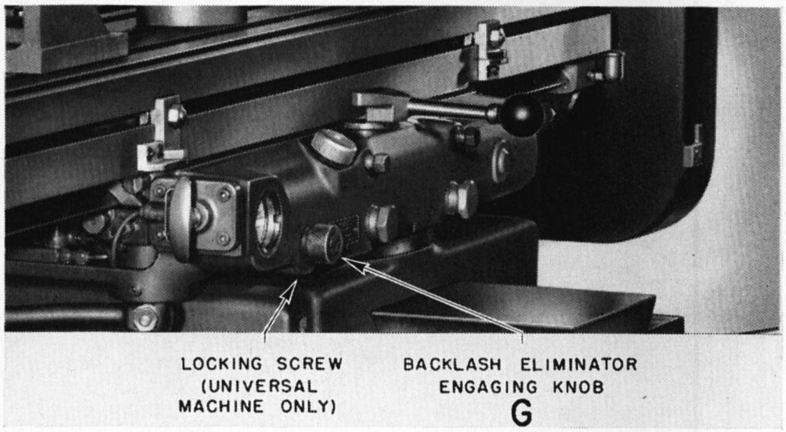
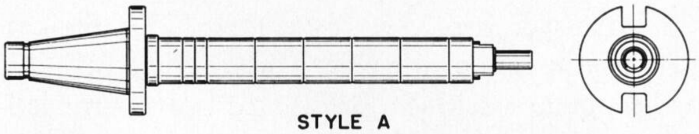


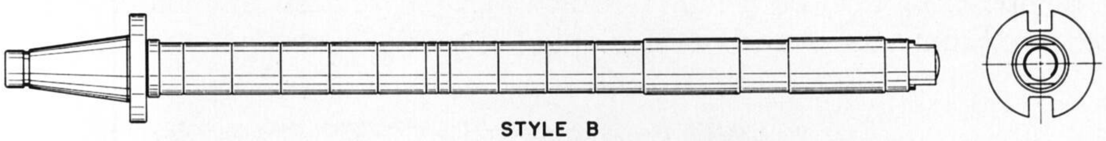
Figure 78A
Front View of Saddle, Showing Backlash Eliminator Engaging Knob. Locking Screw is Also Shown (Universal Machines)

ACCESSORIES AND ATTACHMENTS

ARBORS—"50" Spindle Series



STYLE A



STYLE B

Figure 79A—Conventional Milling Machine Arbors

Catalog Number	Diameter	Style	Usable Length of Cutter Space	Diameter of Bearing Collar	Keyway		Code Name
					Width	Depth	
50- ⅞A10	⅞	A	10	None	. . . .	. . . .	TENAR
50-1 A12	1	A	12	None	¼	5/32	ARTWA
50-1 A15	1	A	15	None	¼	5/32	ARBAA
50-1 A18-4	1	A	18	2⅛	¼	5/32	ATARB
50-1 B18-4	1	B	18	2⅛	¼	5/32	ARBFF
50-1 B24-4	1	B	24	2⅛	¼	5/32	ARBFA
50-1¼A12	1¼	A	12	None	5/16	3/16	ARBCO
50-1¼A15	1¼	A	15	None	5/16	3/16	AROGU
50-1¼A18-4	1¼	A	18	2⅛	5/16	3/16	ARBRU
50-1¼B18-4	1¼	B	18	2⅛	5/16	11/64	BETAR
50-1¼B24-4	1¼	B	24	2⅛	5/16	3/16	ONARB
50-1½B18-4	1½	B	18	2⅛	⅜	7/32	HAFAR
50-1½B24-4	1½	B	24	2⅛	⅜	7/32	FORAR
50-1½B30-4	1½	B	30	2⅛	⅜	7/32	ARBTY
50-1½B36-4	1½	B	36	2⅛	⅜	7/32	ARGOB

ARBOR-LOC SHELL END MILL ARBORS

Catalog No.	Diameter Range of End Mills	Stud Diam.	Code Word
50- ½FCFS	1¼—1½	½	YUWCS
50- ¾FCFS	1¾—2	¾	YUWCT
50-1 FCFS	2¼—2½—2¾	1	YUWCU
50-1¼FCFS	3—3½	1¼	YUWCV
50-1½FCFS	4—4½—5	1½	YUWCW
50-2 FCFS	5½—6	2	YUWCX

ARBOR-LOC COLLETS

(Include Draw-in Bolt)

Catalog No.	Inside Taper	Code Word
50NS—FEB 7FS	No. 7 B. & S.	YUWEA
50NS—FEB 9FS	No. 9 B. & S.	YUWEB
50NS—FEB 10FS	No. 10 B. & S.	YUWEC
50NS—FEB 11FS	No. 11 B. & S.	YUWED
50NS—FEM 2FS	No. 2 Morse	YUWEE
50NS—FEM 3FS	No. 3 Morse	YUWEF
50NS—FEM 4FS	No. 4 Morse	YUWEG

Always Order Arbors by the Code Name and Catalog Number

ARBOR-LOC

Spindle Nose Arrangement

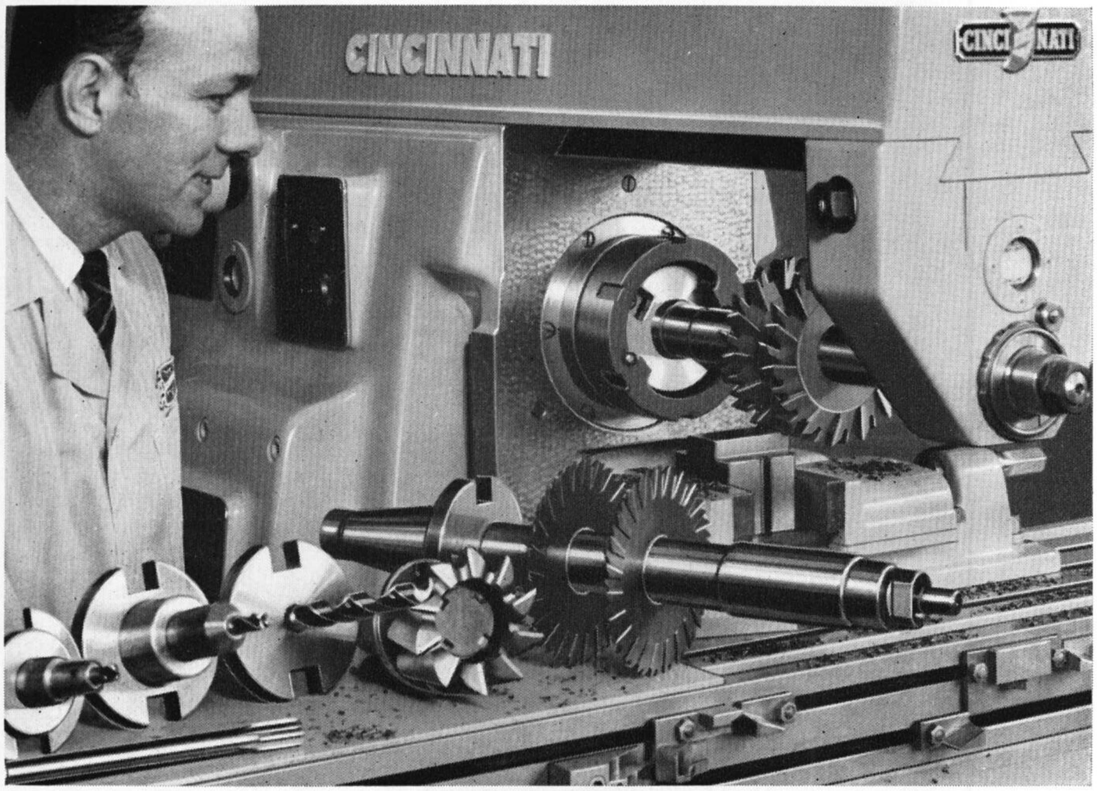


Figure 80A
A wide variety of standard long arbors and adapters may be used interchangeably with the ARBOR-LOC Spindle Nose arrangement.

The ARBOR-LOC Spindle Nose Arrangement is standard equipment on all new ML and MI Milling Machines. This unique design feature enables the operator to quickly change collets, adapters and even long, in seconds to perform a variety of operations on a single toolroom workpiece. (Figure 80A). To insert a cutting tool in the machine spindle nose the operator aligns the ARBOR-LOC adapter nut lugs with driving keys on the spindle nose, he then turns the adapter nut, approximately 15 degrees, to snug cutting tool in place; the cutting tool is securely held in place by using the spanner wrench (Figure 80B) supplied with the machine. The positive stop screw designed in the adapter nut is for the purpose of aligning the adapter nut lugs with driving keys on the spindle nose. This screw seats against small studs on the adapter split ring (Figure 80B) assuring accurate alignment of adapter nut lugs and driving keys of spindle nose. Complete set of ARBOR-LOC parts consists of: adapter spring, adapter split ring, adapter nut and spanner wrench. (Figure 80B).

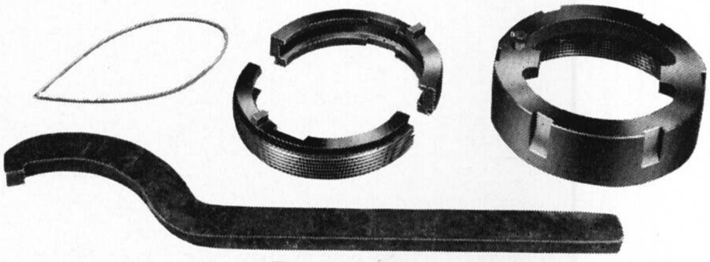


Figure 80B
Complete Set of ARBOR-LOC Parts.

Assembling ARBOR-LOC on Spindle Nose. If the ARBOR-LOC has been removed from the spindle nose for the use of some attachment or for large face milling cutters, it requires but a few minutes to reassemble. Proceed in the following manner.

1. Center the split ring (Figure 81A) on the machine spindle nose driving keys and at the same time fit them in the groove around the spindle.
2. Stretch the adapter spring (Figure 81B) around the split ring, snapping it in the groove designed in these unit parts.
3. Adapter nut is then screwed on split ring.
4. Stop screw, shown in Figure 81C, is then screwed in adapter nut. This screw has a predetermined length for the purpose of eliminating excessive turning of the nut when mounting or removing arbors and adapters. It should be screwed in until the head is seated against the co-bored hole.

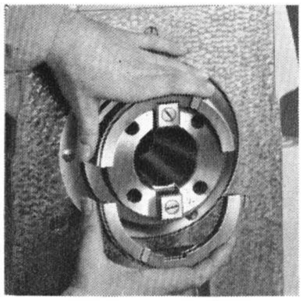


Figure 81A

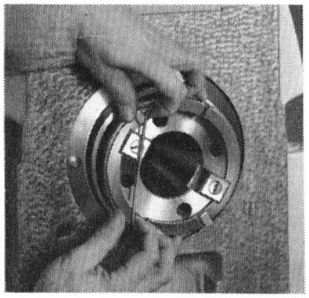


Figure 81B

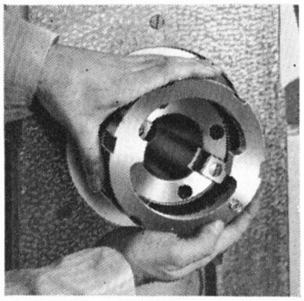


Figure 81C

ARBOR-LOC COLLET ADAPTER
Reducing No. 50 to No. 40 Spindle Series

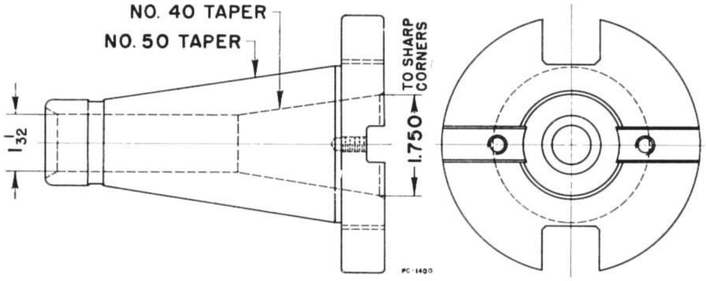


Figure 81D

Arbors and cutters having No. 40 series standard taper shanks may be used on ML and MI Millers with the above adapter.

Outside Taper.................	No. 50 Milling Machine Standard
Inside Taper...................	No. 40 Milling Machine Standard

HIGH NUMBER INDEXING ATTACHMENT

This attachment, shown in Figure 82A, consists of three plates, drilled on both sides. These plates are interchangeable with the standard index plate on the side of the head. They may be applied to the Dividing Head, Spiral Milling Head and Gear Cutting Attachment.

The index tables shown on pages 98-99 apply to the High Number Indexing Attachment.

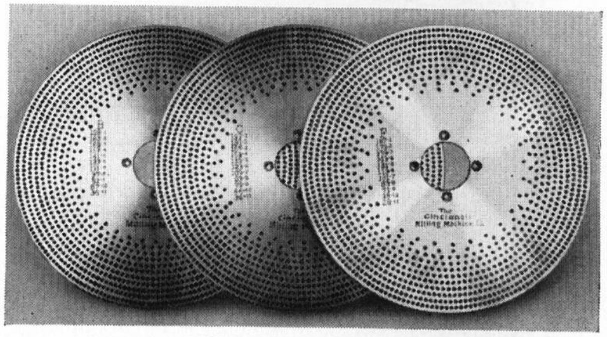


Figure 82A
High Number Indexing Attachment

Number of Holes Drilled in Each Side of High Number Index Plates For Standard and Wide Range Dividing Head

PART NUMBER OF PLATE					
*Standard 10525 †Wide Range 113505		*Standard 10526 †Wide Range 113506		*Standard 10527 †Wide Range 113507	
Side A	**Side B**	**Side C**	**Side D**	**Side E**	**Side F**
189	199	197	193	191	187
177	183	181	179	175	173
171	169	167	163	161	159
147	157	153	151	149	143
129	141	139	137	133	131
117	127	123	121	119	113
99	111	109	107	103	101
91	97	93	89	87	83
69	81	79	77	73	71
48	67	46	44	42	38
30	36	34	32	26	28

***Note:** Available only for the 10″, 12″, 14″ Standard Dividing Heads.
†Available for the 8″, 10″, 12″, 14″ Wide Range Dividers.

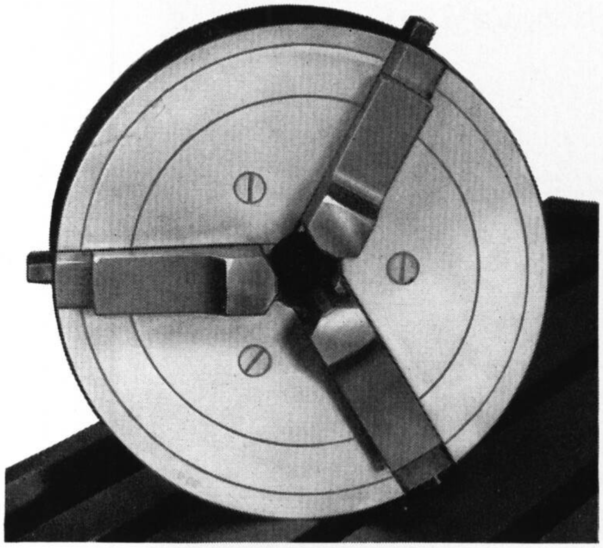


Figure 83A
Dividing Head Chuck

CHUCK

Many Dividing Head jobs can be more conveniently held in a chuck than between centers. To facilitate this class of work, the 3-Jaw Universal Chuck, illustrated in Figure 83A, may be obtained. They can be mounted on various style adapters to fit the spindle nose. Available in 6″ and 9″ sizes.

INDEPENDENT OVERHEAD SPINDLE

This attachment shown in Figure 83B is available for all Cincinnati rectangular overarm machines, new or those in the field. Interchangeable with the standard overarm. Two heads available with or without 90° housing, having a No. 50 N.S. taper spindle.

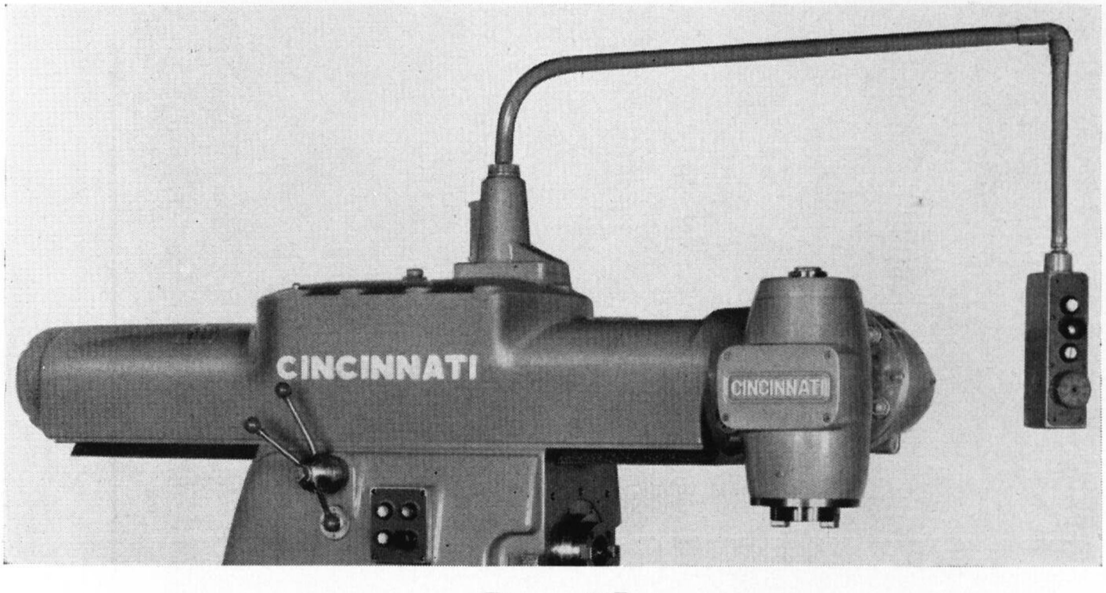


Figure 83B
Independent Overhead Spindle shown with 90° Swivel Housing

COMPENSATING DOG AND DRIVER

The Compensating Dog and Driver, Fig. 84A, may be used with CINCINNATI Dividing Heads and Gear Cutting Heads. With these driving elements, greater accuracy will be obtained on taper work. The tail of the dog has a close fitting roller, which, in turn, fits into the slot of the driver. As the work is indexed, the roller slides on the tail of the dog a sufficient amount to compensate for the varying difference in the distance from the center of the work to the point of driving contact. The dog has a capacity range from $\frac{1}{4}''$ to $2\frac{3}{4}''$ diameter.

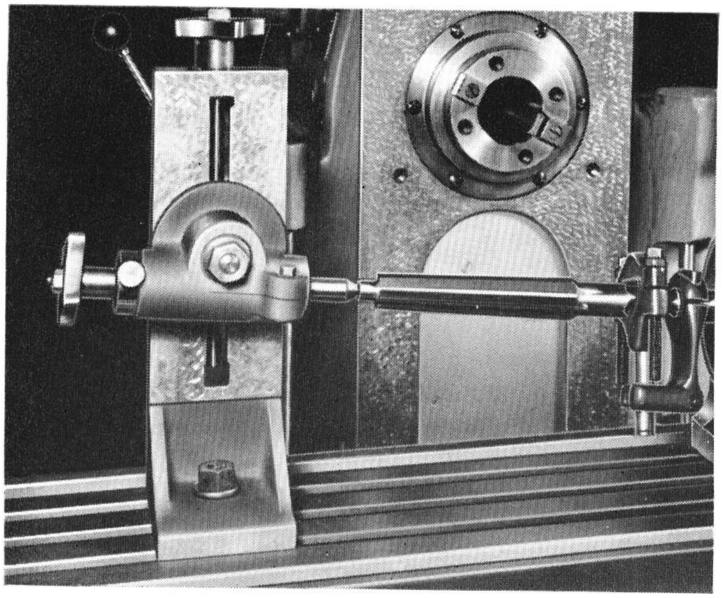


Figure 84A
High Tailstock and Compensating Milling Machine Dog and Driver

HIGH TAILSTOCK

If the work has a steep angle taper and is relatively long, the High Tailstock illustrated in Fig. 84A may be used to advantage. The bracket carrying the center is graduated and can be set at the same angle as the work.

Maximum distance, table to center point—$11\frac{1}{32}''$

Minimum distance, table to center point—$3\frac{21}{32}''$

RAISING BLOCKS

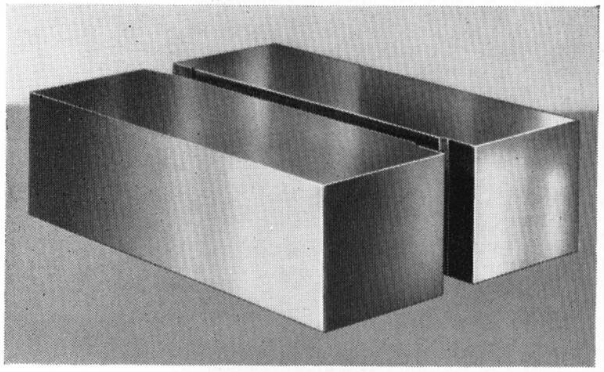


Figure 85A
Raising Block

Raising blocks, illustrated in Fig. 85A, may be placed under the Dividing Head and Tailstock to obtain an increase in range. These blocks are flat, parallel, and of equal height, (supplied only in matched pairs) and give the head and tailstock a substantial support.

SPECIFICATIONS

Size * Head	Height of Blocks	Width T-Slots	Headstock Block		Tailstock Block	
			Length	Width	Length	Width
10″	3″	13/16″ and 11/16″	10¼″	7⅝″	6⅛″	5½″
12″	2½″	13/16″	12 9/16″	9¼″	6⅝″	6⅛″

*Available also for an 8″ Dividing Head.

ANGLE PLATE

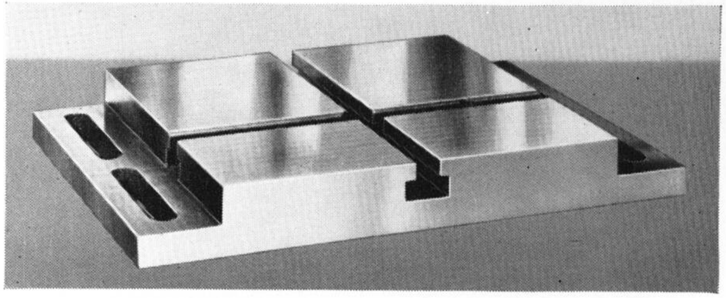


Figure 85B
Angle Plate

Angle Plates, illustrated in Fig. 85B, are convenient for many types of set-ups involving a Dividing Head or small fixture placed off-center or at an angle to the table T-slots. The T-slots are standard size and at right angles to each other.

SPECIFICATIONS

Height of * Plate	Width T-Slot	Working Surface	Size Over All
1 13/16″	11/16″	10¼″ x 10⅛″	10¼″ x 14⅛″
2⅛″	13/16″	12½″ x 12⅜″	12½″ x 16⅝″

*Available also for an 8″ Dividing Head.

PLAIN AND SWIVEL VISES

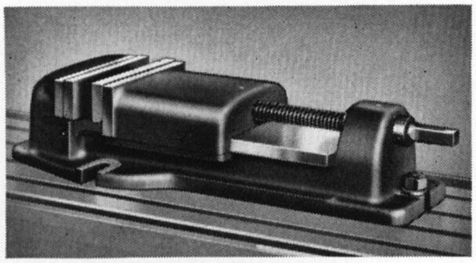


Figure 86A
Plain Vise

The plain vise is illustrated in Fig. 86A. With the exception of a swivel plate under the body, swivel vises are the same as plain vises. When ordering a vise, give width of T-slot in the table of the machine on which it is to be used.

SPECIFICATIONS FOR PLAIN AND SWIVEL VISES

Size	Depth Jaws	Width Jaws	Jaws Open	Overall Height		Net Weight	
				Plain	Swivel	Plain	Swivel
No. 3	1⅝"	6⅛"	4"	4¼"	6"	59 lbs.	79 lbs.

ALL STEEL VISE

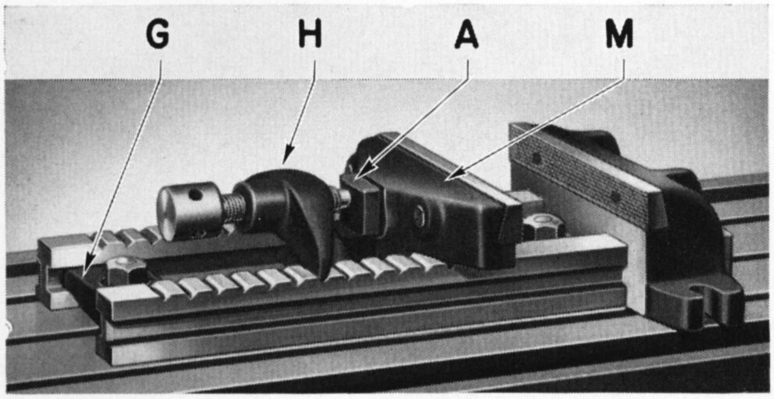


Figure 86B
All-Steel Vise

The CINCINNATI All-Steel Vise very effectively and conveniently holds heavy work, easily withstanding the most severe duty imposed on it by the machine. It can be set lengthwise or crosswise on the table. Screw holder "H", Fig. 86B, and movable jaw "M" can be quickly set to give approximately the correct opening of the jaws. Plate "A" is hardened to withstand the pressure from the clamping screw. There are four clamping lugs on the solid jaw and one movable clamp "G". Jaw "M" can be swiveled, thus adapting it to the irregularities in rough castings or forgings. The jaws are serrated and hardened, assuring a firm grip on the work piece.

SPECIFICATIONS FOR ALL-STEEL VISE

Size	Distance from Table to Top of Vise Jaws	Net Weight	Shipping Weight	Code Word
10" x 10" x 2"	4"	80 lbs.	110 lbs.	BYVIS

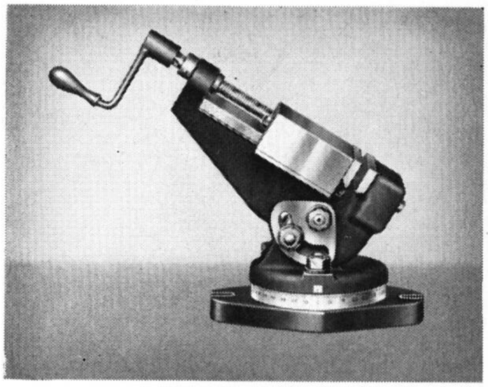


Figure 87A
Toolmaker's Universal Vise

TOOL MAKER'S UNIVERSAL VISE

For general tool room work. Can be swiveled in vertical plane up to and including 90 degrees—360 degrees in a horizontal plane. Maximum opening 3½″; depth of jaws 1⅝″; width of jaws 6⅛″; net weight 75 pounds.

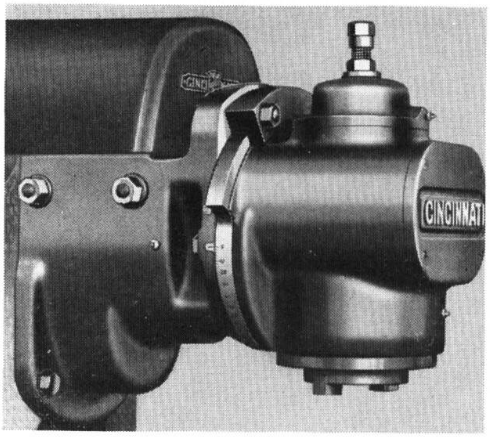


Figure 87B
Vertical Milling Attachment

VERTICAL MILLING ATTACHMENT

Ideal for face milling where there is not enough work to keep a Vertical Milling Machine busy. Spindle speeds same as machine. Spindle nose same as machine spindle nose. Swivel range 90° total (45° either way from the vertical). Lubricate with good grade of cup grease.

CIRCULAR MILLING ATTACHMENT

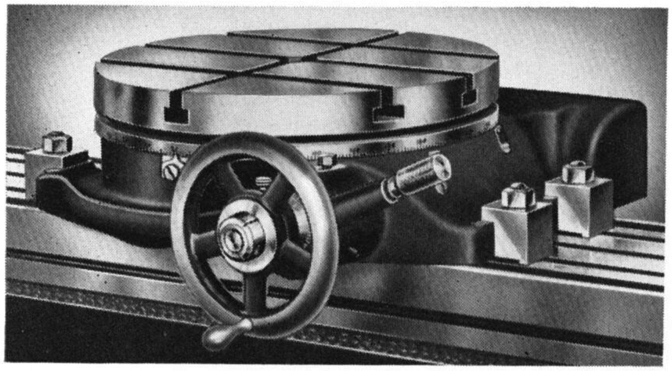


Figure 87C
16″ Hand Feed
Circular Milling Attachment

The two most popular sizes are 12″ and 16″, although the 20″ size can be applied to Nos. 307–14 and 410-14 MI machines. Hand or power feed. Power feed attachments have both power and manual controls; two-direction feed; dogs for feed trip. Table of attachment is graduated in degrees to facilitate angular settings. Easy to set up. Gives you the equivalent of a rotary table miller. May be used on vertical or horizontal machines.

SPIRAL MILLING HEAD
(and Gear Cutting Attachment)

The Spiral Milling Head is shown in Figure 88A. When the bracket for connecting the driving mechanism (shown at the extreme right) is omitted, the head is known as the "Gear Cutting Attachment". Of course, the type of work-piece milled on the latter attachment is limited to those requiring indexing only, such as spur gears. These heads are suitable for heavy and continuous gear cutting. All index and lead tables in this booklet apply to the Spiral Milling Head. The index tables shown on pages 97-99 apply to the Gear Cutting Attachment.

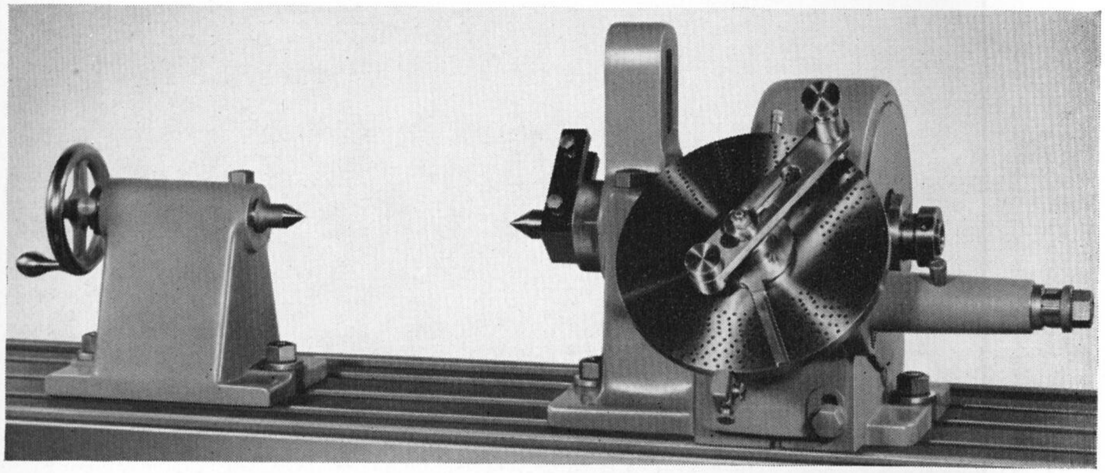


Figure 88A
Spiral Milling Head

Specifications for Spiral Milling Heads and Gear Cutting Attachments

Size of Head	Actual Swing	Taper Hole in Spindle	Overall Length of Tailstock	Overall Length of Head
12″	12½″	11 B&S	9⅜″	15⅝″

UNIVERSAL SPIRAL MILLING ATTACHMENT

This attachment is used for helical milling in two cases:

1. If the machine is a plain miller, obviously the table can not be swiveled to bring the work piece to the correct helix angle with the cutter. It then becomes necessary to swivel the cutter. This angular setting is obtained by means of the auxiliary Universal Spiral Milling Attachment. (Fig. 89A).
2. The table of a universal miller can not be swiveled more than 45°. If the helix angle exceeds this range, the attachment must be used, since it allows the cutter to be swiveled through a complete circle.

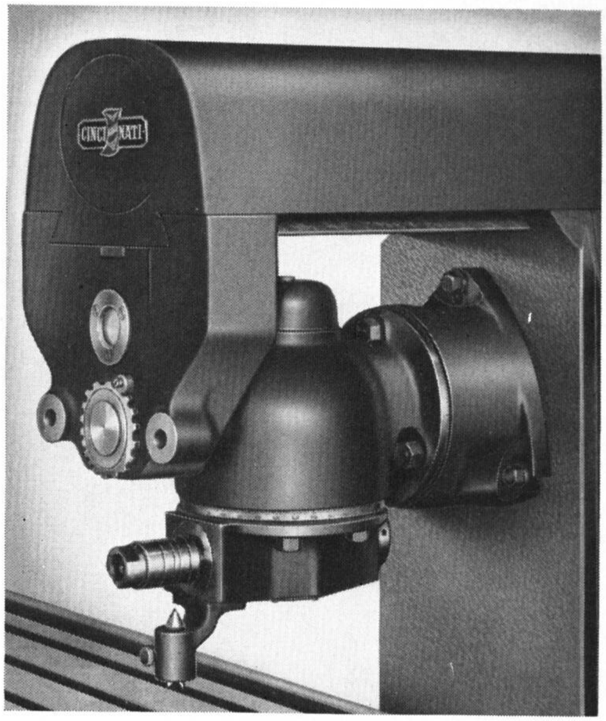


Figure 89A
Universal Spiral Milling Attachment

The Universal Spiral Milling Attachment may also be employed for a wide variety of other types of work, such as vertical milling with a shell end mill, rounding out keyways, milling angular surfaces, etc. The attachment spindle runs at the same speed as the machine spindle.

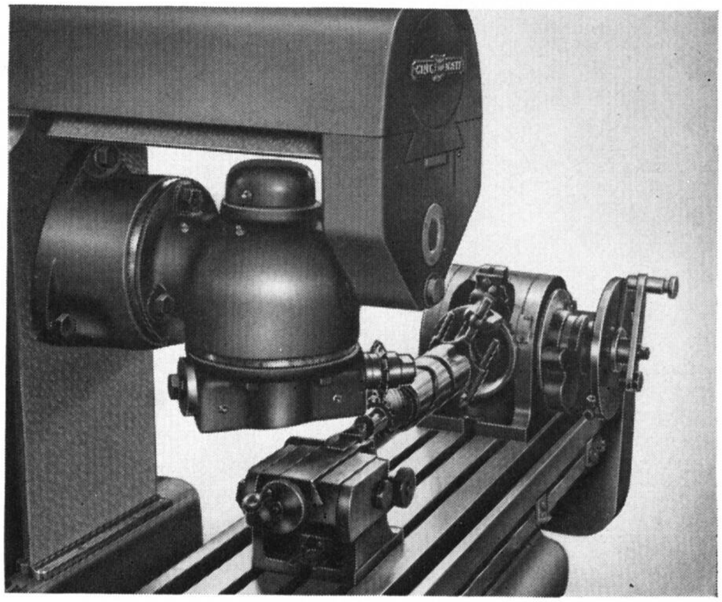


Figure 89B
Universal Spiral Milling Attachment and Dividing Head Set Up for Milling the Helical Gear Teeth on a Cam Shaft

MOUNTING THE UNIVERSAL SPIRAL MILLING ATTACHMENT

To mount the Universal Spiral Milling Attachment on the machine proceed as follows:

1. Turn the machine spindle until the driving keys are in a horizontal position (Figure 90A).
2. Insert the arbor into the attachment and raise the attachment to the face of the column with a crane. Align the key-slots on the arbor with the driving keys on the spindle.
3. Push the attachment toward the column until a portion of the arbor enters the machine spindle nose. Insert the draw-in bolt through the spindle and partially screw it into the arbor.
4. Carefully push the attachment toward the column face. Raise or lower the crane to align the bracket of the attachment with the dust ring around the machine spindle.
5. Pull the draw-in bolt until the arbor key-slots engage with the driving keys on the spindle. Tighten the lock nut on the draw-in bolt.
6. Fasten the attachment to the column face with the cap screws provided.
7. Mount the arbor support on the end of the overarm and move the overarm back with the pilot wheel until the arbor support fits over the plug in the attachment.

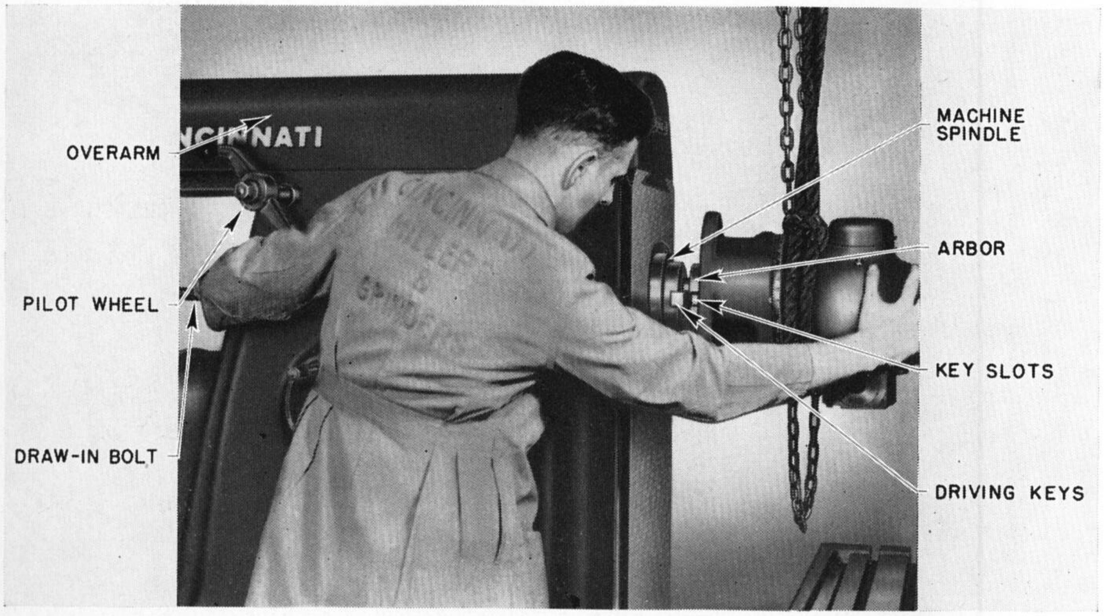


Figure 90A
Mounting the Universal Spiral Milling Attachment

HIGH SPEED UNIVERSAL MILLING ATTACHMENT

The High Speed Universal Milling Attachment is shown in Fig. 91A. This attachment is for comparatively light work, and is not suitable for face milling operations.

Specifications

Attachment spindle speed:
Speed dial reading x 1⅔

Swivel range:
Parallel to face of machine column; 360°
Right angles to face of machine column; 90°

Taper holes for cutter:
Attachment spindle; No. 40 National Standard
Quill spindle (extra cost); No. 7 B. & S.

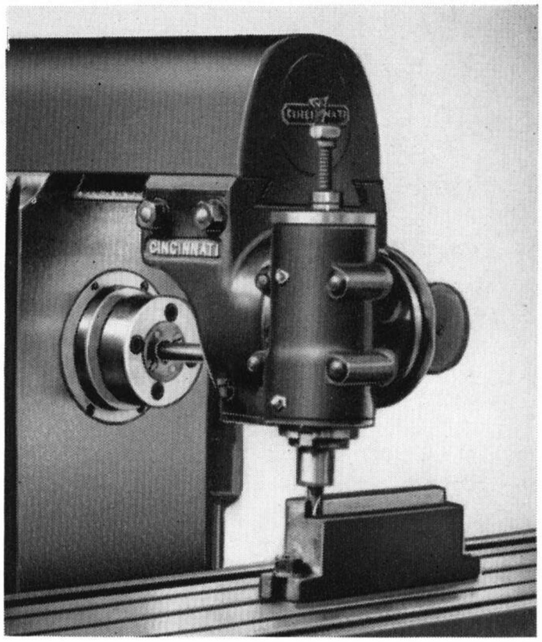


Figure 91A
High Speed Universal Milling Attachment

The standard attachment is shown in Fig. 91A.

If the attachment is equipped with a quill device, and it is desirable to remove it so that cutters can be inserted in the standard end of the attachment spindle, proceed in the following manner:

1. Loosen the Allen head set screw in the periphery of hand quill feed knob. Tap the screw lightly to loosen the lock shoe beneath it.
2. In the top end of the knob is an adjusting nut. With a spanner wrench, remove this nut.
3. A slotted adjusting nut is now visible. Remove this nut and its lock washer.

4. Grasp the cutter shank end of the quill and pull it down through the attachment. Replace lock nut and washer, so that they will not be lost. To protect ball bearings, also replace lock nut in hand feed knob.

5. Through the body of the attachment, near the quill nut assembly, you will find a set screw. Remove this set screw.

6. Screw the remainder of the quill device out of the body of the attachment.

7. Now fit the dust cover in place, and lock it with the set screw.

8. Assemble two driving keys in the attachment spindle.

9. Remove the plate on the attachment housing at the rear end of the spindle. It is held in position with four screws.

10. Drive draw-in bolt centering bush into rear end of spindle.

11. Replace cap.

Lubrication. The Universal High Speed Milling Attachment must be lubricated daily while in use. Two grease cups are provided for the spindle bearings. Use only medium sponge short fibre grease, sodium soap base. There are also four grease nipples on the attachment proper, and one oil button in the hand quill feed knob. Periodically apply cup grease and machine oil, respectively.

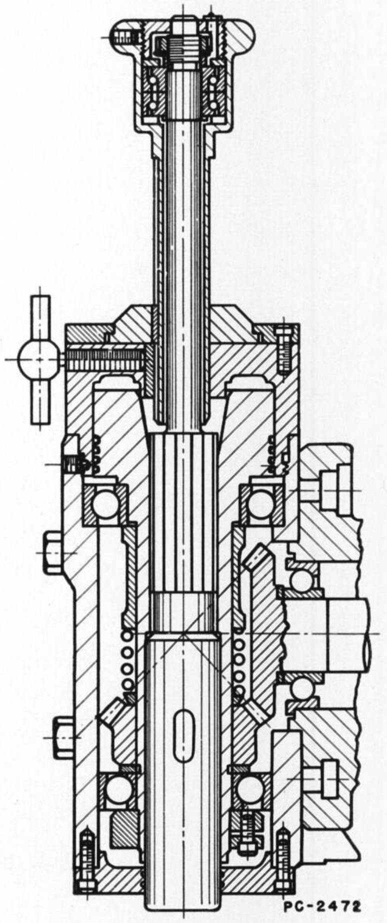


Figure 92A
Section Through Universal High Speed Milling Attachment with Quill Device

METHOD OF CALCULATING MACHINING TIME

The actual cutting time for milling any piece of work may be calculated from the following formula.

$$T = \frac{L + A + O}{F}$$

T = Actual Milling Time in Minutes.
L = Length of Cut in Inches.
A = Approach of Cutter in Inches.
O = Over-travel of Cutter in Inches.
F = Feed in Inches per Minute.

The approach of the cutter is the distance the table must move the work into the cutter before full cutting depth or width is attained. (Dimension "A" in Figures 94A, 94B, and 95A.)

The over-travel of the cutter is the distance the table must travel in power feed minus the total length of the cut. It is a safety factor to allow for variations in the length of the work piece and in clamping.

The feed is the most important factor, but there are such wide variations in feed depending upon the cutter, material, and the method of holding the work that the judgment of the set up man or operator must be relied upon to determine the correct feed. A discussion of feeds and speeds is contained in our booklet "Milling Machine Practice" a copy of which may be obtained free of charge.

Example: Suppose a cast-iron bracket is to be milled on one side, under the following conditions of feed, length of cut, etc. Calculate the actual cutting time.

Length of Cut	8″
Width of Cut	4″
Diameter of End Mill	6″
Over-travel	assume ¼″
Feed	11″ per minute

Then L = 8″
A = .77″ (See table entitled "Approach of Cutter for End Mills and Face Mills", page 95.)
O = ¼″
F = 11″

$$\text{And } T = \frac{8+.77+.25}{11} = .82 \text{ minutes.}$$

Total time, floor to floor = .82 + Handling Time + Time to Clear Work of Cutters.

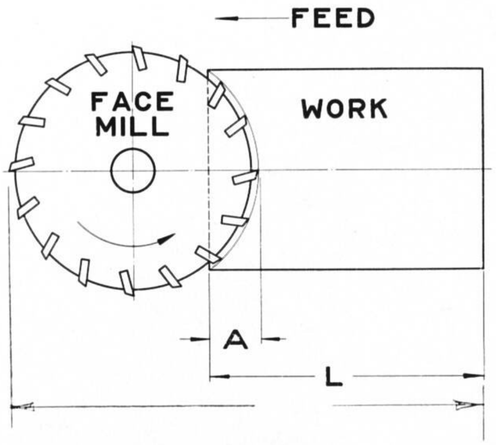


Figure 94A
Approach of Cutter (A) for Face and End Mills, with Center of Cutter Approximately in Line with Center of Work.

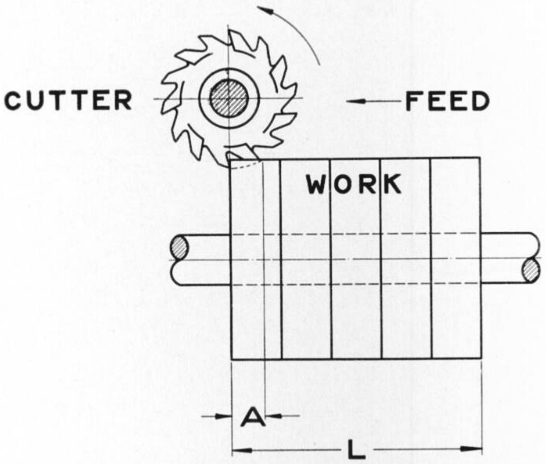


Figure 94B
Approach of Cutter (A) for Slab Milling, Keywaying, Gear Cutting, Sawing, etc.

Example: Suppose a gang of five gear blanks are to be milled between the centers of a 10″ Dividing Head, under the following conditions of feed, depth of cut, etc. Calculate the actual cutting time.

Width of Gear Face	1″
Whole Depth of Tooth	.270″
Diameter of Cutter	2¾″
Over-travel	assume ⅛″
Feed	9″ per minute

Then L = 5″ (Five gears, each 1″ wide)
A = .79″ (See table entitled "Approach of Cutter for Spiral Mills, Keyway Cutters, Saws, etc.", page 96)
O = ⅛″
F = 9″

$$\text{And T per tooth} = \frac{5 + .79 + .125}{9} = .66 \text{ minutes}$$

Total time floor to floor:

$$= \frac{(.66 \times \text{No. of teeth}) + (\text{indexing time for one tooth} \times \text{No. of teeth} - 1).}{5}$$

$$+ \frac{\text{handling time} + \text{time to clear work of cutters.}}{5}$$

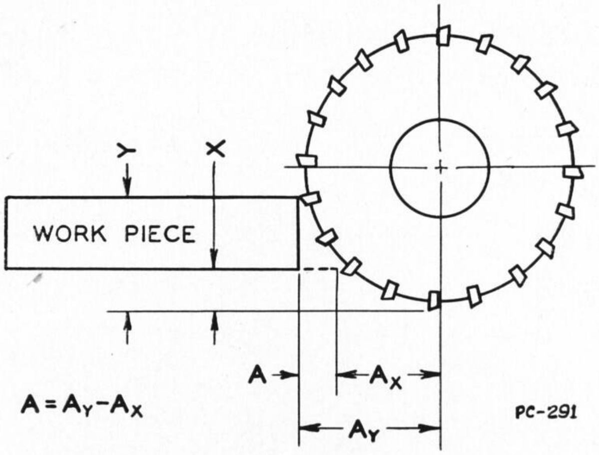


Figure 95A
Approach of Cutter(A) for Face and End Mills, with Center of Cutter Offset from Center of Work.

Example: If we have a part which requires a cut with an end mill or a face mill, and the center-line of the work does not coincide with the center of the cutter, Figure 95A, the approach cannot be read directly from the table. Assuming an extreme condition, suppose we have an 8″ diameter face mill taking a 2½″ width of cut, and that one edge of the work is 1½″ from the periphery of the cutter (dimension "X" in Figure 95A), while the opposite edge is 4″ from the periphery (dimension "Y" = 1½″ + 2½″). Then the approach of the cutter is the difference between the approach for a 4″ depth of cut and a 1½″ depth of cut. In the table entitled "Approach of Cutter for Spiral Mills, Keyway Cutters, Saws, etc.", the approach for an 8″ cutter at a 4″ depth is 4″, while at a 1½″ depth, it is 3.12″. The difference between 4″ and 3.12″ equals .88″, the correct approach in this particular case.

Approach of Cutter for End Mills and Face Mills
(Center of Cutter Approximately in Line with Center of Work)

Diam. of Mill	WIDTH OF CUT											
	1″	2″	3″	4″	5″	6″	7″	8″	9″	10″	11″	12″
1	.5											
1½	.192											
2	.135	1.										
2½	.105	.5										
3	.09	.37	1.5									
4	.07	.27	.68	2.								
5	.05	.24	.5	1.	2.5							
6	.04	.18	.4	.77	1.34	3.						
7½	.04	.14	.32	.59	.96	1.51	2.63					
8	.033	.13	.291	.54	.88	1.36	2.07	4.				
10	.025	.10	.23	.43	.56	1.00	1.43	2.	2.82	5.		
12	.020	.08	.19	.35	.54	.81	1.13	1.53	2.04	2.69	3.6	6.

How to Read the Table: Follow down the column headed "Diam. of Mill" until you come to the diameter of cutter which you are using. Follow across to the right until you come to the column under the **width** of cut which the cutter is taking. The figure given is the approach of the cutter.

Example: 10″ diameter face mill; 8″ width of cut; approach of cutter is 2″.

Approach of Cutter for Spiral Mills, Keyway Cutters, Saws, Etc.

Diam. of Mill	DEPTH OF CUT											
	1/16"	1/8"	3/16"	1/4"	3/8"	1/2"	3/4"	1"	1½"	2"	3"	4"
1¼	.272	.37	.44	.50	.57	.612						
1½	.299	.41	.49	.56	.65	.71	.75					
1¾	.32	.45	.54	.61	.72	.79	.87					
2	.35	.48	.58	.66	.78	87	.97	1.00				
2¼	.37	.52	.62	.71	.84	.93	1.06	1.12				
2½	.39	.54	.66	.75	.89	1.00	1.15	1.22				
2¾	.41	.57	.69	.79	.94	1.06	1.22	1.32				
3	.43	.60	.73	.83	.99	1.12	1.30	1.41	1.50			
3¼	.45	.63	.76	.87	1.04	1.17	1.37	1.50	1.62			
3½	.46	.65	.79	.91	1.08	1.22	1.44	1.58	1.73			
3¾	.48	.67	.82	.93	1.13	1.28	1.50	1.66	1.84			
4	.49	.70	.85	.97	1.17	1.32	1.56	1.73	1.94	2.00		
4¼	.51	.72	.87	1.00	1.21	1.37	1.62	1.80	2.03	2.12		
4½	.53	.74	.90	1.03	1.24	1.41	1.67	1.87	2.12	2.24		
4¾	.54	.76	.92	1.06	1.28	1.46	1.73	1.93	2.21	2.35		
5	.56	.78	.95	1.09	1.32	1.50	1.79	2.00	2.29	2.45		
5½	.58	.82	1.00	1.14	1.39	1.58	1.89	2.12	2.45	2.64		
6	.61	.86	1.04	1.20	1.45	1.66	1.98	2.24	2.60	2.83	3 00	
6½	.634	.89	1.09	1.25	1.51	1.73	2.08	2.35	2.74	3.00	3 24	
7	.658	.93	1.13	1.30	1.58	1.80	2.17	2.45	2.87	3.16	3.46	
7½	.68	.95	1.17	1.35	1.63	1.87	2.25	2.55	3.00	3.32	3.67	
8	.71	.99	1.21	1.39	1.69	1.94	2.33	2.65	3.12	3.46	3.87	4.00
8½	.73	1.03	1.25	1.44	1.74	2.00	2.41	2.74	3.24	3.61	4.06	4.24
9	.75	1.05	1.28	1.48	1.80	2.06	2.49	2.83	3.36	3.74	4.24	4.47
9½	.77	1.08	1.32	1.52	1.85	2.12	2.56	2.92	3.47	3.88	4.42	4.69
10	.79	1.11	1.35	1.56	1.90	2.18	2.63	3.00	3.57	4.00	4.58	4.90
10½	.81	1.14	1.39	1.60	1.95	2.24	2.71	3.08	3.67	4.12	4.75	5.10
11	.83	1.17	1.42	1.64	2.00	2.29	2.77	3.16	3.77	4.24	4.89	5.29
11½	.85	1.19	1.46	1.68	2.04	2.34	2.84	3.24	3.87	4.36	5.04	5.48
12	.86	1.22	1.49	1.72	2.09	2.40	2.91	3.32	3.97	4.47	5.19	5.65

How to Read the Table—Follow down the column headed "Diam. of Mill" until you come to the diameter of cutter which you are using. Follow across to the right until you come to the column under the **depth** of cut which the cutter is taking. The figure given is the approach of the cutter.

Example: 2¾" diameter cutter, ¼" depth of cut; approach of cutter is .79".

INDEX TABLES (Numerical Divisions)

For Standard Dividing Head Plate and Wide Range Divider

(See pages 18 and 19 for method of calculating angular spacings and divisions not listed for the Wide Range Divider)

Table of divisions obtainable with the standard Index Plate and the large plate of the Wide Range Divider, used with Dividing Heads, Gear Cutting Attachments, Spiral Milling Heads and Plain Centers.

The plates are drilled on both sides with circles of holes equally spaced. The number of holes in the circles are as follows:

Standard Dividing Head Plate	**First Side**—24-25-28-30-34-37-38-39-41-42-43 **Second Side**—46-47-49-51-53-54-57-58-59-62-66
Large Plate of Wide Range Divider	**First Side**—24-28-30-34-37-38-39-41-42-43-100 **Second Side**—46-47-49-51-53-54-57-58-59-62-66

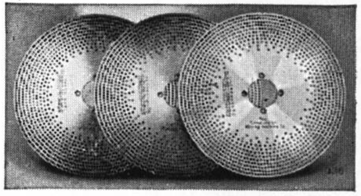
No. of Divisions	Circle	Turns	Spaces	No. of Divisions	Circle	Turns	Spaces	No. of Divisions	Circle	Spaces	No. of Divisions	Circle	Spaces	No. of Divisions	Circle	Spaces	No. of Divisions	Circle	Spaces
2	Any	20	....	37	37	1	3	80	24	12	148	37	10	248	62	10	460	46	4
3	24	13	8	38	38	1	2	82	41	20	150	30	8	250	25	4	464	58	5
4	Any	10	....	39	39	1	1	84	42	20	152	38	10	255	51	8	470	47	4
5	Any	8	....	40	Any	1	....	85	34	16	155	62	16	260	39	6	472	59	5
6	24	6	16	41	41	....	40	86	43	20	156	39	10	264	66	10	480	24	2
7	28	5	20	42	42	....	40	88	66	30	160	28	7	270	54	8	490	49	4
8	Any	5	....	43	43	....	40	90	54	24	164	41	10	272	34	5	496	62	5
9	54	4	24	44	66	....	60	92	46	20	165	66	16	280	28	4	500	25	2
10	Any	4	....	45	54	....	48	94	47	20	168	42	10	290	58	8	510	51	4
11	66	3	42	46	46	....	40	95	38	16	170	34	8	296	37	5	520	39	3
12	24	3	8	47	47	....	40	96	24	10	172	43	10	300	30	4	528	66	5
13	39	3	3	48	24	....	20	98	49	20	176	66	15	304	38	5	530	53	4
14	49	2	42	49	49	....	40	100	25	10	180	54	12	310	62	8	540	54	4
15	24	2	16	50	25	....	20	102	51	20	184	46	10	312	39	5	560	28	2
16	24	2	12	51	51	....	40	104	39	15	185	37	8	320	24	3	570	57	4
17	34	2	12	52	39	....	30	105	42	16	188	47	10	328	41	5	580	58	4
18	54	2	12	53	53	....	40	106	53	20	190	38	8	330	66	8	590	59	4
19	38	2	4	54	54	....	40	108	54	20	192	24	5	336	42	5	600	30	2
20	Any	2	....	55	66	....	48	110	66	24	195	39	8	340	34	4	620	62	4
21	42	1	38	56	28	....	20	112	28	10	196	49	10	344	43	5	660	66	4
22	66	1	54	57	57	....	40	114	57	20	200	30	6	360	54	6	680	34	2
23	46	1	34	58	58	....	40	115	46	16	204	51	10	368	46	5	720	54	3
24	24	1	16	59	59	....	40	116	58	20	205	41	8	370	37	4	740	37	2
25	25	1	15	60	24	....	16	118	59	20	210	42	8	376	47	5	760	38	2
26	39	1	21	62	62	....	40	120	24	8	212	53	10	380	38	4	780	39	2
27	54	1	26	64	24	....	15	124	62	20	215	43	8	390	39	4	820	41	2
28	42	1	18	65	39	....	24	125	25	8	216	54	10	392	49	5	840	42	2
29	58	1	22	66	66	....	40	130	39	12	220	66	12	400	30	3	860	43	2
30	24	1	8	68	34	....	20	132	66	20	224	28	5	408	51	5	880	66	3
31	62	1	18	70	28	....	16	135	54	16	228	57	10	410	41	4	920	46	2
32	28	1	7	72	54	....	30	136	34	10	230	46	8	420	42	4	940	47	2
33	66	1	14	74	37	....	20	140	28	8	232	58	10	424	53	5	960	24	1
34	34	1	6	75	30	....	16	144	54	15	235	47	8	430	43	4	980	49	2
35	28	1	4	76	38	....	20	145	58	16	236	59	10	432	54	5	1000	25	1
36	54	1	6	78	39	....	20				240	24	4	440	66	6			
											245	49	8	456	57	5			

INDEX TABLE (Numerical Divisions)

FOR HIGH NUMBER INDEXING ATTACHMENT

Indexes all numbers up to and including 200; all even numbers and those divisible by 5 up to and including 400, except 225, 275, 325, 375.
This attachment consists of a set of 3 index plates which are drilled on six sides, A, B, C, D, E and F.
Example to index 35 divisions—This division can be made from side F, D, A or E. The preferred side is F, since this requires the least number of holes. But should either D, A or E be in place, it can be used, thus avoiding the bother of changing plates.

No. of Div.	Side	Circle	Turns	Spaces	No. of Div.	Side	Circle	Turns	Spaces	No. of Div.	Side	Circle	Spaces	No. of Div.	Side	Circle	Spaces
2	Any	Any	20	....	19	F	38	2	4	41	C	123	120	70	D	42	24
3	A	30	13	10	19	E	133	2	14	42	E	42	40	70	A	91	52
3	B	36	13	12	19	A	171	2	18	42	A	147	140	70	E	119	68
3	E	42	13	14	20	Any	Any	2	....	43	A	129	120	71	F	71	40
3	C	93	13	31	21	E	42	1	38	44	D	44	40	72	B	36	20
3	F	159	13	53	21	A	147	1	133	44	A	99	90	72	A	117	65
4	Any	Any	10	....	22	D	44	1	36	44	F	143	130	72	C	153	85
5	Any	Any	8	....	22	A	99	1	81	45	B	36	32	73	E	73	40
6	A	30	6	20	22	F	143	1	117	45	A	99	88	74	B	111	60
6	B	36	6	24	23	C	46	1	34	45	C	153	136	75	A	30	16
6	E	42	6	28	23	A	69	1	51	46	C	46	40	76	F	38	20
6	C	93	6	62	23	E	161	1	119	46	A	69	60	76	E	133	70
6	F	159	6	106	24	A	30	1	20	46	E	161	140	76	A	171	90
7	F	28	5	20	24	B	36	1	24	47	B	141	120	77	D	77	40
7	E	42	5	30	24	E	42	1	28	48	A	30	25	78	A	117	60
7	D	77	5	55	24	C	93	1	62	48	B	36	30	79	C	79	40
7	A	91	5	65	24	F	159	1	106	49	A	147	120	80	E	26	13
8	Any	Any	5	....	25	A	30	1	18	50	A	30	24	80	F	28	14
9	B	36	4	16	25	E	175	1	105	50	E	175	140	80	A	30	15
9	A	99	4	44	26	E	26	1	14	51	C	153	120	80	D	32	16
9	C	153	4	68	26	A	91	1	49	52	E	26	20	80	C	34	17
10	Any	Any	4	....	26	B	169	1	91	52	A	91	70	80	B	36	18
11	D	44	3	28	27	B	81	1	39	52	F	143	110	80	E	42	21
11	A	99	3	63	27	A	189	1	91	52	B	169	130	81	B	81	40
11	F	143	3	91	28	F	28	1	12	53	F	159	120	82	C	123	60
12	A	30	3	10	28	E	42	1	18	54	B	81	60	83	F	83	40
12	B	36	3	12	28	D	77	1	33	54	A	189	140	84	E	42	20
12	E	42	3	14	28	A	91	1	39	55	D	44	32	84	A	147	70
12	C	93	3	31	29	E	87	1	33	55	F	143	104	85	C	34	16
12	F	159	3	53	30	A	30	1	10	56	F	28	20	85	E	119	56
13	E	26	3	2	30	B	36	1	12	56	E	42	30	85	F	187	88
13	A	91	3	7	30	E	42	1	14	56	D	77	55	86	A	129	60
13	F	143	3	11	30	C	93	1	31	56	A	91	65	87	E	87	40
13	B	169	3	13	30	F	159	1	53	57	A	171	120	88	D	44	20
14	F	28	2	24	31	C	93	1	27	58	E	87	60	88	A	99	45
14	E	42	2	36	32	F	28	1	7	59	A	177	120	88	F	143	65
14	D	77	2	66	32	D	32	1	8	60	A	30	20	89	D	89	40
14	A	91	2	78	32	B	36	1	9	60	B	36	24	90	B	36	16
15	A	30	2	20	32	A	48	1	12	60	E	42	28	90	A	99	44
15	B	36	2	24	33	A	99	1	21	60	F	159	106	90	C	153	68
15	E	42	2	28	34	C	34	1	6	61	B	183	120	91	A	91	40
15	C	93	2	62	34	E	119	1	21	62	C	93	60	92	C	46	20
15	F	159	2	106	34	F	187	1	33	63	A	189	120	92	A	69	30
16	E	26	2	13	35	F	28	1	4	64	D	32	20	92	E	161	70
16	F	28	2	14	35	D	77	1	11	64	A	48	30	93	C	93	40
16	A	30	2	15	35	A	91	1	13	65	E	26	16	94	B	141	60
16	D	32	2	16	35	E	119	1	17	65	A	91	56	95	F	38	16
16	C	34	2	17	36	B	36	1	4	65	F	143	88	95	E	133	56
16	B	36	2	18	36	A	99	1	11	65	B	169	104	95	A	171	72
17	C	34	2	12	36	C	153	1	17	66	A	99	60	96	B	36	15
17	E	119	2	42	37	B	111	1	9	67	B	67	40	96	A	48	20
17	C	153	2	54	38	F	38	1	2	68	C	34	20	97	B	97	40
17	F	187	2	66	38	E	133	1	7	68	E	119	70	98	A	147	60
18	B	36	2	8	38	A	171	1	9	68	F	187	110	99	A	99	40
18	A	99	2	22	39	A	117	1	3	69	A	69	40	100	A	30	12
18	C	153	2	34	40	Any	Any	1	....	70	F	28	16	100	E	175	70



INDEX TABLE—(Concluded)

FOR HIGH NUMBER INDEXING ATTACHMENT

Fig. 99A . . . The High Number Indexing Attachment is used by replacing the standard index plate with the High Number plate which will give you the number of divisions required. (See Note Page 71)

No. of Div.	Side	Circle	Spaces	No. of Div.	Side	Circle	Spaces	No. of Div.	Side	Circle	Spaces	No. of Div.	Side	Circle	Spaces	No. of Div.	Side	Circle	Spaces
101	F	101	40	137	D	137	40	180	C	153	34	240	E	42	7	320	A	48	6
102	C	153	60	138	A	69	20	181	C	181	40	240	A	48	8	322	E	161	20
103	E	103	40	139	C	139	40	182	A	91	20	242	D	121	20	324	B	81	10
104	E	26	10	140	F	28	8	183	B	183	40	244	B	183	30	326	D	163	20
104	A	91	35	140	E	42	12	184	C	46	10	245	A	147	24	328	C	123	15
104	F	143	55	140	D	77	22	184	A	69	15	246	C	123	20	330	A	99	12
104	B	169	65	140	A	91	26	184	E	161	35	248	C	93	15	332	F	83	10
105	E	42	16	141	B	141	40	185	B	111	24	250	E	175	28	334	C	167	20
105	A	147	56	142	F	71	20	186	C	93	20	252	A	189	30	335	B	67	8
106	F	159	60	143	F	143	40	187	F	187	40	254	B	127	20	336	E	42	5
107	D	107	40	144	B	36	10	188	B	141	30	255	C	153	24	338	B	169	20
108	B	81	30	145	E	87	24	189	A	189	40	256	D	32	5	340	C	34	4
108	A	189	70	146	E	73	20	190	F	38	8	258	A	129	20	340	E	119	14
109	C	109	40	147	A	147	40	190	E	133	28	260	E	26	4	340	F	187	22
110	D	44	16	148	B	111	30	190	A	171	36	260	A	91	14	342	A	171	20
110	A	99	36	149	E	149	40	191	E	191	40	260	F	143	22	344	A	129	15
100	F	143	52	150	A	30	8	192	A	48	10	260	B	169	26	345	A	69	8
111	B	111	40	151	D	151	40	193	D	193	40	262	F	131	20	346	F	173	20
112	F	28	10	152	F	38	10	194	B	97	20	264	A	99	15	348	E	87	10
112	E	42	15	152	E	133	35	195	A	117	24	265	F	159	24	350	E	175	20
113	F	113	40	152	A	171	45	196	A	147	30	266	E	133	20	352	D	44	5
114	A	171	60	153	C	153	40	197	C	197	40	268	B	67	10	354	A	177	20
115	C	46	16	154	D	77	20	198	A	99	20	270	B	81	12	355	F	71	8
115	A	69	24	155	C	93	24	199	B	199	40	270	A	189	28	356	D	89	10
115	E	161	56	156	A	117	30	200	A	30	6	272	C	34	5	358	D	179	20
116	E	87	30	157	B	157	40	200	E	175	35	274	D	137	20	360	B	36	4
117	A	117	40	158	C	79	20	202	F	101	20	276	A	69	10	360	A	99	11
118	A	177	60	159	F	159	40	204	C	153	30	278	C	139	20	360	C	153	17
119	E	119	40	160	F	28	7	205	C	123	24	280	F	28	4	362	C	181	20
120	A	30	10	160	D	32	8	206	E	103	20	280	E	42	6	364	A	91	10
120	B	36	12	160	B	36	9	208	E	26	5	280	D	77	11	365	E	73	8
120	E	42	14	160	A	48	12	210	E	42	8	280	A	91	13	366	B	183	20
120	C	93	31	161	E	161	40	210	A	147	28	282	B	141	20	368	C	46	5
120	F	159	53	162	B	81	20	212	F	159	30	284	F	71	10	370	B	111	12
121	D	121	40	163	D	163	40	214	D	107	20	235	A	171	24	372	C	93	10
122	B	183	60	164	C	123	30	215	A	129	24	286	F	143	20	374	F	187	20
123	C	123	40	165	A	99	24	216	B	81	15	288	B	36	5	376	B	141	15
124	C	93	30	166	F	83	20	216	A	189	35	290	E	87	12	378	A	189	20
125	E	175	56	167	C	167	40	218	C	109	20	292	E	73	10	380	F	38	4
126	A	189	60	168	E	42	10	220	D	44	8	294	A	147	20	380	E	133	14
127	B	127	40	168	A	147	35	220	A	99	18	295	A	177	24	380	A	171	18
128	D	32	10	169	B	169	40	220	F	143	26	296	B	111	15	382	E	191	20
128	A	48	15	170	C	34	8	222	B	111	20	298	E	149	20	384	A	48	5
129	A	129	40	170	E	119	28	224	F	28	5	300	A	30	4	385	D	77	8
130	E	26	8	170	F	187	44	226	F	113	20	302	D	151	20	386	D	193	20
130	A	91	28	171	A	171	40	228	A	171	30	304	F	38	5	388	B	97	10
130	F	143	44	172	A	129	30	230	C	46	8	305	B	183	24	390	A	117	12
130	B	169	52	173	F	173	40	230	A	69	12	306	C	153	20	392	A	147	15
131	F	131	40	174	E	87	20	230	E	161	28	308	D	77	10	394	C	197	20
132	A	99	30	175	E	175	40	232	E	87	15	310	C	93	12	395	C	79	8
133	E	133	40	176	D	44	10	234	A	117	20	312	A	117	15	396	A	99	10
134	B	67	20	177	A	177	40	235	B	141	24	314	B	157	20	398	B	199	20
135	B	81	24	178	D	89	20	236	A	177	30	315	A	189	24	400	A	30	3
135	A	189	56	179	D	179	40	238	E	119	20	316	C	79	10	....	....	....	....
136	C	34	10	180	B	36	8	240	A	30	5	318	F	159	20	....	....	....	....
136	E	119	35	180	A	99	22	240	B	36	6	320	D	32	4	....	....	....	..

TABLE OF ANGULAR DIVISIONS
Obtainable With Standard Dividing Head and Wide Range Divider

(Use 54-hole circle on large plate)

DEGREES

Degrees	Turns of Crank B	Spaces Crank B	Degrees	Turns of Crank B	Spaces Crank B	Degrees	Turns of Crank B	Spaces Crank B	Degrees	Turns of Crank B	Spaces Crank B	Degrees	Turns of Crank B	Spaces Crank B	Degrees	Turns of Crank B	Spaces Crank B	Degrees	Turns of Crank B	Spaces Crank B	Degrees	Turns of Crank B	Spaces Crank B	Degrees	Turns of Crank B	Spaces Crank B
1	....	6	41	4	30	81	9	....	121	13	24	161	17	48	201	22	18	241	26	42	281	31	12	321	35	36
2	....	12	42	4	36	82	9	6	122	13	30	162	18	....	202	22	24	242	26	48	282	31	18	322	35	42
3	....	18	43	4	42	83	9	12	123	13	36	163	18	6	203	22	30	243	27	....	283	31	24	323	35	48
4	....	24	44	4	48	84	9	18	124	13	42	164	18	12	204	22	36	244	27	6	284	31	30	324	36	....
5	....	30	45	5	....	85	9	24	125	13	48	165	18	18	205	22	42	245	27	12	285	31	36	325	36	6
6	....	36	46	5	6	86	9	30	126	14	....	166	18	24	206	22	48	246	27	18	286	31	42	326	36	12
7	....	42	47	5	12	87	9	36	127	14	6	167	18	30	207	23	....	247	27	24	287	31	48	327	36	18
8	....	48	48	5	18	88	9	42	128	14	12	168	18	36	208	23	6	248	27	30	288	32	....	328	36	24
9	1	....	49	5	24	89	9	48	129	14	18	169	18	42	209	23	12	249	27	36	289	32	6	329	36	30
10	1	6	50	5	30	90	10	....	130	14	24	170	18	48	210	23	18	250	27	42	290	32	12	330	36	36
11	1	12	51	5	36	91	10	6	131	14	30	171	19	....	211	23	24	251	27	48	291	32	18	331	36	42
12	1	18	52	5	42	92	10	12	132	14	36	172	19	6	212	23	30	252	28	....	292	32	24	332	36	48
13	1	24	53	5	48	93	10	18	133	14	42	173	19	12	213	23	36	253	28	6	293	32	30	333	37	....
14	1	30	54	6	....	94	10	24	134	14	48	174	19	18	214	23	42	254	28	12	294	32	36	334	37	6
15	1	36	55	6	6	95	10	30	135	15	....	175	19	24	215	23	48	255	28	18	295	32	42	335	37	12
16	1	42	56	6	12	96	10	36	136	15	6	176	19	30	216	24	....	256	28	24	296	32	48	336	37	18
17	1	48	57	6	18	97	10	42	137	15	12	177	19	36	217	24	6	257	28	30	297	33	....	337	37	24
18	2	....	58	6	24	98	10	48	138	15	18	178	19	42	218	24	12	258	28	36	298	33	6	338	37	30
19	2	6	59	6	30	99	11	....	139	15	24	179	19	48	219	24	18	259	28	42	299	33	12	339	37	36
20	2	12	60	6	36	100	11	6	140	15	30	180	20	....	220	24	24	260	28	48	300	33	18	340	37	42
21	2	18	61	6	42	101	11	12	141	15	36	181	20	6	221	24	30	261	29	....	301	33	24	341	37	48
22	2	24	62	6	48	102	11	18	142	15	42	182	20	12	222	24	36	262	29	6	302	33	30	342	38	....
23	2	30	63	7	....	103	11	24	143	15	48	183	20	18	223	24	42	263	29	12	303	33	36	343	38	6
24	2	36	64	7	6	104	11	30	144	16	....	184	20	24	224	24	48	264	29	18	304	33	42	344	38	12
25	2	42	65	7	12	105	11	36	145	16	6	185	20	30	225	25	....	265	29	24	305	33	48	345	38	18
26	2	48	66	7	18	106	11	42	146	16	12	186	20	36	226	25	6	266	29	30	306	34	....	346	38	24
27	3	....	67	7	24	107	11	48	147	16	18	187	20	42	227	25	12	267	29	36	307	34	6	347	38	30
28	3	6	68	7	30	108	12	....	148	16	24	188	20	48	228	25	18	268	29	42	308	34	12	348	38	36
29	3	12	69	7	36	109	12	6	149	16	30	189	21	....	229	25	24	269	29	48	309	34	18	349	38	42
30	3	18	70	7	42	110	12	12	150	16	36	190	21	6	230	25	30	270	30	....	310	34	24	350	38	48
31	3	24	71	7	48	111	12	18	151	16	42	191	21	12	231	25	36	271	30	6	311	34	30	351	39	....
32	3	30	72	8	....	112	12	24	152	16	48	192	21	18	232	25	42	272	30	12	312	34	36	352	39	6
33	3	36	73	8	6	113	12	30	153	17	....	193	21	24	233	25	48	273	30	18	313	34	42	353	39	12
34	3	42	74	8	12	114	12	36	154	17	6	194	21	30	234	26	....	274	30	24	314	34	48	354	39	18
35	3	48	75	8	18	115	12	42	155	17	12	195	21	36	235	26	6	275	30	30	315	35	....	355	39	24
36	4	....	76	8	24	116	12	48	156	17	18	196	21	42	236	26	12	276	30	36	316	35	6	356	39	30
37	4	6	77	8	30	117	13	....	157	17	24	197	21	48	237	26	18	277	30	42	317	35	12	357	39	36
38	4	12	78	8	36	118	13	6	158	17	30	198	22	....	238	26	24	278	30	48	318	35	18	358	39	42
39	4	18	79	8	42	119	13	12	159	17	36	199	22	6	239	26	30	279	31	....	319	35	24	359	39	48
40	4	24	80	8	48	120	13	18	160	17	42	200	22	12	240	26	36	280	31	6	320	35	30	360	40	....

TABLE OF ANGULAR DIVISIONS . . . Obtainable With Wide Range Divider

(Use 54-hole circle on small plate)

FRACTIONS OF A DEGREE

Minutes	Seconds	Turns of Crank D	Spaces Crank D	Minutes	Seconds	Turns of Crank D	Spaces Crank D	Minutes	Seconds	Turns of Crank D	Spaces Crank D	Minutes	Seconds	Turns of Crank D	Spaces Crank D	Minutes	Seconds	Turns of Crank D	Spaces Crank D	Minutes	Seconds	Turns of Crank D	Spaces Crank D	Minutes	Seconds	Turns of Crank D	Spaces Crank D	Minutes	Seconds	Turns of Crank D	Spaces Crank D
0	6	....	1	8	...	1	26	16	...	2	52	24	...	4	24	32	...	5	50	40	...	7	22	48	...	8	48	56	...	10	20
0	12	....	2	8	12	1	28	16	12	3	....	24	12	4	26	32	12	5	52	40	12	7	24	48	12	8	50	56	12	10	22
0	24	....	4	8	24	1	30	16	24	3	2	24	24	4	28	32	24	6	....	40	24	7	26	48	24	8	52	56	24	10	24
0	36	....	6	8	36	1	32	16	36	3	4	24	36	4	30	32	36	6	2	40	36	7	28	48	36	9	....	56	36	10	26
0	48	....	8	8	48	1	34	16	48	3	6	24	48	4	32	32	48	6	4	40	48	7	30	48	48	9	2	56	48	10	28
1	...	....	10	9	...	1	36	17	...	3	8	25	...	4	34	33	...	6	6	41	...	7	32	49	...	9	4	57	...	10	30
1	12	....	12	9	12	1	38	17	12	3	10	25	12	4	36	33	12	6	8	41	12	7	34	49	12	9	6	57	12	10	32
1	24	....	14	9	24	1	40	17	24	3	12	25	24	4	38	33	24	6	10	41	24	7	36	49	24	9	8	57	24	10	34
1	36	....	16	9	36	1	42	17	36	3	14	25	36	4	40	33	36	6	12	41	36	7	38	49	36	9	10	57	36	10	36
1	48	....	18	9	48	1	44	17	48	3	16	25	48	4	42	33	48	6	14	41	48	7	40	49	48	9	12	57	48	10	38
2	...	....	20	10	...	1	46	18	...	3	18	26	...	4	44	34	...	6	16	42	...	7	42	50	...	9	14	58	...	10	40
2	12	....	22	10	12	1	48	18	12	3	20	26	12	4	46	34	12	6	18	42	12	7	44	50	12	9	16	58	12	10	42
2	24	....	24	10	24	1	50	18	24	3	22	26	24	4	48	34	24	6	20	42	24	7	46	50	24	9	18	58	24	10	44
2	36	....	26	10	36	1	52	18	36	3	24	26	36	4	50	34	36	6	22	42	36	7	48	50	36	9	20	58	36	10	46
2	48	....	28	10	48	2	....	18	48	3	26	26	48	4	52	34	48	6	24	42	48	7	50	50	48	9	22	58	48	10	48
3	...	....	30	11	...	2	2	19	...	3	28	27	...	5	....	35	...	6	26	43	...	7	52	51	...	9	24	59	...	10	50
3	12	....	32	11	12	2	4	19	12	3	30	27	12	5	2	35	12	6	28	43	12	8	....	51	12	9	26	59	12	10	52
3	24	....	34	11	24	2	6	19	24	3	32	27	24	5	4	35	24	6	30	43	24	8	2	51	24	9	28	59	24	11	....
3	36	....	36	11	36	2	8	19	36	3	34	27	36	5	6	35	36	6	32	43	36	8	4	51	36	9	30	59	36	11	2
3	48	....	38	11	48	2	10	19	48	3	36	27	48	5	8	35	48	6	34	43	48	8	6	51	48	9	32	59	48	11	4
4	...	....	40	12	...	2	12	20	...	3	38	28	...	5	10	36	...	6	36	44	...	8	8	52	...	9	34	...	...	....	....
4	12	....	42	12	12	2	14	20	12	3	40	28	12	5	12	36	12	6	38	44	12	8	10	52	12	9	36	...	...	....	....
4	24	....	44	12	24	2	16	20	24	3	42	28	24	5	14	36	24	6	40	44	24	8	12	52	24	9	38	...	...	....	....
4	36	....	46	12	36	2	18	20	36	3	44	28	36	5	16	36	36	6	42	44	36	8	14	52	36	9	40	...	...	....	....
4	48	....	48	12	48	2	20	20	48	3	46	28	48	5	18	36	48	6	44	44	48	8	16	52	48	9	42	...	...	....	....
5	...	....	50	13	...	2	22	21	...	3	48	29	...	5	20	37	...	6	46	45	...	8	18	53	...	9	44	...	...	....	....
5	12	....	52	13	12	2	24	21	12	3	50	29	12	5	22	37	12	6	48	45	12	8	20	53	12	9	46	...	...	....	....
5	24	1	....	13	24	2	26	21	24	3	52	29	24	5	24	37	24	6	50	45	24	8	22	53	24	9	48	...	...	....	....
5	36	1	2	13	36	2	28	21	36	4	....	29	36	5	26	37	36	6	52	45	36	8	24	53	36	9	50	...	...	....	....
5	48	1	4	13	48	2	30	21	48	4	2	29	48	5	28	37	48	7	....	45	48	8	26	53	48	9	52	...	...	....	....
6	...	1	6	14	...	2	32	22	...	4	4	30	...	5	30	38	...	7	2	46	...	8	28	54	...	10	....	...	...	....	....
6	12	1	8	14	12	2	34	22	12	4	6	30	12	5	32	38	12	7	4	46	12	8	30	54	12	10	2	...	...	....	....
6	24	1	10	14	24	2	36	22	24	4	8	30	24	5	34	38	24	7	6	46	24	8	32	54	24	10	4	...	...	....	....
6	36	1	12	14	36	2	38	22	36	4	10	30	36	5	36	38	36	7	8	46	36	8	34	54	36	10	6	...	...	....	....
6	48	1	14	14	48	2	40	22	48	4	12	30	48	5	38	38	48	7	10	46	48	8	36	54	48	10	8	...	...	....	....
7	...	1	16	15	...	2	42	23	...	4	14	31	...	5	40	39	...	7	12	47	...	8	38	55	...	10	10	...	...	....	....
7	12	1	18	15	12	2	44	23	12	4	16	31	12	5	42	39	12	7	14	47	12	8	40	55	12	10	12	...	...	....	....
7	24	1	20	15	24	2	46	23	24	4	18	31	24	5	44	39	24	7	16	47	24	8	42	55	24	10	14	...	...	....	....
7	36	1	22	15	36	2	48	23	36	4	20	31	36	5	46	39	36	7	18	47	36	8	44	55	36	10	16	...	...	....	....
7	48	1	24	15	48	2	50	23	48	4	22	31	48	5	48	39	48	7	20	47	48	8	46	55	48	10	18	...	...	....	....

NOTE.—When indexing degrees and fractions of a degree, Cranks "B" and "D" in above tables (indicated in Figure 71A, page 71) are both moved in the same direction

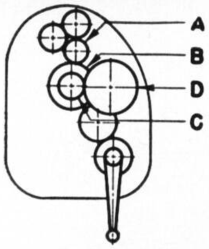


TABLE OF LEADS (2.500 to 3.800)

Lead of Spiral in Inches	A	B	C	D	Lead of Spiral in Inches	A	B	C	D	Lead of Spiral in Inches	A	B	C	D
2.500	27	45	20	48	**2.923**	19	39	27	45	**3.385**	22	39	27	45
2.507	22	39	20	45	**2.927**	19	51	33	42	**3.389**	22	42	33	51
2.510	24	45	24	51	**2.930**	20	39	24	42	**3.394**	21	33	24	45
2.513	19	36	20	42	**2.941**	24	51	30	48	**3.399**	39	45	20	51
2.516	21	36	22	51	**2.946**	22	42	27	48	**3.409**	27	33	20	48
2.521	20	42	27	51	**2.956**	21	30	19	45	**3.415**	33	36	19	51
2.530	17	42	30	48	**2.966**	22	51	33	48	**3.422**	24	33	24	51
2.534	21	39	24	51	**2.976**	20	48	30	42	**3.429**	24	42	27	45
2.540	20	42	24	45	**2.986**	22	39	27	51	**3.437**	27	36	22	48
2.546	22	36	20	48	**2.991**	20	36	21	39	**3.440**	22	27	19	45
2.552	22	39	19	42	**2.995**	21	33	24	51	**3.451**	24	30	22	51
2.561	19	51	33	48	**3.000**	21	55	33	42	**3.457**	21	27	20	45
2.567	24	33	18	51	**3.009**	22	45	24	39	**3.462**	27	39	24	48
2.574	21	48	30	51	**3.017**	20	51	30	39	**3.472**	30	36	20	48
2.579	19	39	27	51	**3.025**	24	42	27	51	**3.480**	30	39	19	42
2.588	22	51	27	45	**3.029**	21	39	27	48	**3.486**	24	27	20	51
2.593	21	36	20	45	**3.039**	18	55	39	42	**3.492**	30	42	22	45
2.598	24	39	19	45	**3.048**	24	42	24	45	**3.500**	36	45	21	48
2.608	21	30	19	51	**3.056**	22	45	30	48	**3.505**	39	48	22	51
2.614	20	51	30	45	**3.068**	27	33	18	48	**3.516**	24	39	24	42
2.619	22	42	24	48	**3.077**	20	39	27	45	**3.526**	30	39	22	48
2.625	21	45	27	48	**3.081**	22	51	30	42	**3.535**	21	33	20	36
2.632	21	39	22	45	**3.088**	21	51	36	48	**3.543**	24	33	19	39
2.639	19	45	30	48	**3.096**	22	30	19	45	**3.556**	24	36	24	45
2.647	24	48	27	51	**3.105**	30	36	19	51	**3.565**	30	33	20	51
2.655	22	39	24	51	**3.111**	24	36	21	45	**3.571**	30	42	24	48
2.661	19	51	30	42	**3.117**	24	33	18	42	**3.580**	27	33	21	48
2.667	24	45	24	48	**3.125**	21	42	30	48	**3.590**	42	39	17	51
2.674	21	36	22	48	**3.134**	20	36	22	39	**3.595**	30	36	22	51
2.679	20	42	27	48	**3.143**	22	42	27	45	**3.603**	21	48	42	51
2.689	24	42	24	51	**3.152**	19	51	33	39	**3.611**	39	36	17	51
2.696	22	51	30	48	**3.163**	22	45	33	51	**3.620**	30	39	24	51
2.707	20	36	19	39	**3.173**	27	39	22	48	**3.626**	27	39	22	42
2.715	20	39	27	51	**3.182**	24	33	21	48	**3.636**	24	33	24	48
2.727	21	33	18	42	**3.189**	19	55	36	39	**3.641**	39	42	20	51
2.735	24	39	20	45	**3.199**	20	33	19	36	**3.650**	33	39	22	51
2.745	24	36	21	51	**3.205**	20	39	30	48	**3.660**	24	27	21	51
2.750	22	45	27	48	**3.214**	24	48	27	42	**3.667**	24	30	22	48
2.764	19	55	36	45	**3.223**	22	39	24	42	**3.676**	39	42	19	48
2.773	22	42	27	51	**3.231**	27	39	21	45	**3.686**	22	27	19	42
2.778	20	45	30	48	**3.239**	27	33	19	48	**3.692**	27	39	24	45
2.784	24	39	19	42	**3.248**	19	45	30	39	**3.697**	33	42	24	51
2.794	22	42	24	45	**3.258**	27	39	24	51	**3.702**	33	39	21	48
2.801	20	42	30	51	**3.263**	21	33	20	39	**3.706**	27	30	21	51
2.812	21	42	27	48	**3.268**	30	36	20	51	**3.714**	39	42	18	45
2.820	22	39	24	48	**3.274**	22	48	30	42	**3.720**	19	55	42	39
2.824	24	51	27	45	**3.282**	24	39	24	45	**3.730**	24	33	20	39
2.831	21	51	33	48	**3.284**	21	27	19	45	**3.739**	22	51	39	45
2.842	19	36	21	39	**3.291**	21	39	22	36	**3.743**	30	33	21	51
2.851	21	39	27	51	**3.297**	20	39	27	42	**3.750**	18	45	..	48
2.857	24	42	24	48	**3.309**	27	48	30	51	**3.753**	24	27	19	45
2.866	19	39	30	51	**3.318**	22	51	30	39	**3.761**	30	39	22	45
2.876	22	51	30	45	**3.329**	17	55	42	39	**3.765**	24	30	24	51
2.879	24	33	19	48	**3.333**	21	42	30	45	**3.770**	30	36	19	42
2.885	20	39	27	48	**3.346**	21	51	39	48	**3.775**	33	36	21	51
2.896	24	39	24	51	**3.353**	27	30	19	51	**3.782**	30	42	27	51
2.903	19	45	33	48	**3.361**	22	45	33	48	**3.788**	30	33	20	48
2.910	20	36	22	42	**3.369**	27	33	21	51	**3.792**	39	45	21	48
2.917	21	45	30	48	**3.377**	20	55	39	42	**3.800**	27	30	19	45

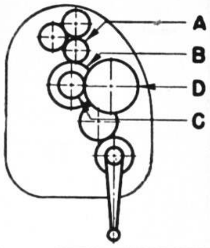


TABLE OF LEADS (3.810 to 5.025)

Lead of Spiral in Inches	A	B	C	D	Lead of Spiral in Inches	A	B	C	D	Lead of Spiral in Inches	A	B	C	D
3.810	30	42	24	45	4.202	45	42	20	51	4.606	36	33	19	45
3.818	27	33	21	45	4.215	17	55	45	33	4.615	18	42	..	39
3.824	39	42	21	51	4.222	19	42	..	45	4.622	33	42	30	51
3.828	33	39	19	42	4.231	33	39	24	48	4.628	20	55	42	33
3.834	24	27	22	51	4.235	27	30	24	51	4.635	39	33	20	51
3.838	30	33	19	45	4.242	30	33	21	45	4.643	39	42	24	48
3.843	21	51	42	45	4.248	39	36	20	51	4.646	42	39	22	51
3.850	27	33	24	51	4.256	39	42	22	48	4.656	24	27	22	42
3.860	21	51	45	48	4.263	42	39	19	48	4.662	30	33	20	39
3.869	39	42	20	48	4.267	24	30	24	45	4.667	21	39	..	45
3.878	33	39	22	48	4.274	30	36	20	39	4.673	39	36	22	51
3.882	27	30	22	51	4.278	33	36	21	45	4.678	39	33	19	48
3.889	30	36	21	45	4.286	18	45	..	42	4.687	30	36	27	48
3.897	36	39	19	45	4.293	30	33	17	36	4.691	30	27	19	45
3.911	24	30	22	45	4.299	45	39	19	51	4.701	30	36	22	39
3.916	24	33	21	39	4.308	36	39	21	45	4.706	24	36	..	51
3.922	20	48	..	51	4.314	22	45	..	51	4.711	19	55	45	33
3.929	33	42	24	48	4.318	36	33	19	48	4.714	33	42	27	45
3.937	27	30	21	48	4.327	30	39	27	48	4.722	17	42	..	36
3.949	33	39	21	45	4.333	39	45	24	48	4.727	39	33	18	45
3.954	33	36	22	51	4.344	36	39	24	51	4.740	39	36	21	48
3.958	19	45	..	48	4.354	33	30	19	48	4.745	33	30	22	51
3.963	30	33	17	39	4.364	27	33	24	45	4.751	21	51	45	39
3.968	30	36	20	42	4.370	24	42	39	51	4.762	20	39	..	42
3.972	39	45	22	48	4.375	21	45	..	48	4.773	36	33	21	48
3.977	30	33	21	48	4.387	22	27	21	39	4.777	17	55	51	33
3.982	33	39	24	51	4.392	24	45	42	51	4.786	42	39	20	45
3.986	27	33	19	39	4.396	30	39	24	42	4.793	30	27	22	51
3.992	45	42	19	51	4.400	27	30	22	45	4.800	27	30	24	45
4.000	27	36	24	45	4.406	27	33	21	39	4.807	19	48	51	42
4.006	39	42	22	51	4.412	30	36	27	51	4.813	30	33	27	51
4.011	33	36	21	48	4.420	33	42	27	48	4.821	36	42	27	48
4.018	30	42	27	48	4.429	30	33	19	39	4.827	48	39	20	51
4.021	24	27	19	42	4.434	42	39	21	51	4.835	33	39	24	42
4.029	30	39	22	42	4.444	20	42	..	45	4.843	39	30	19	51
4.034	36	42	24	51	4.453	27	24	19	48	4.848	30	33	24	45
4.040	30	33	20	45	4.461	39	36	21	51	4.853	33	36	27	51
4.048	17	39	..	42	4.466	33	36	19	39	4.858	27	22	19	48
4.060	30	36	19	39	4.471	36	30	19	51	4.866	39	33	21	51
4.064	36	33	19	51	4.476	24	33	24	39	4.875	39	30	18	48
4.072	30	39	27	51	4.480	33	39	27	51	4.887	36	39	27	51
4.078	24	45	39	51	4.486	19	48	51	45	4.895	30	33	21	39
4.083	21	48	42	45	4.492	36	33	21	51	4.902	45	36	20	51
4.091	27	33	21	42	4.500	27	30	24	48	4.911	33	42	30	48
4.098	33	30	19	51	4.508	42	33	17	48	4.916	27	42	39	51
4.103	30	39	24	45	4.514	39	36	20	48	4.922	27	24	21	48
4.113	30	33	19	42	4.524	19	45	..	42	4.926	42	36	19	45
4.118	21	48	..	51	4.529	33	30	21	51	4.935	36	33	19	42
4.125	33	45	27	48	4.533	36	30	17	45	4.941	36	30	21	51
4.136	21	55	39	36	4.540	39	42	22	45	4.945	30	39	27	42
4.147	33	36	19	42	4.547	42	39	19	45	4.948	45	36	19	48
4.156	24	33	24	42	4.553	33	27	19	51	4.952	39	42	24	45
4.160	33	42	27	51	4.558	24	27	20	39	4.959	20	55	45	33
4.167	20	39	..	48	4.567	45	39	19	48	4.967	48	36	19	51
4.171	39	33	18	51	4.571	36	42	24	45	4.977	33	39	30	51
4.176	36	39	19	42	4.575	42	36	20	51	4.990	39	33	19	45
4.183	20	51	48	45	4.583	22	39	..	48	5.000	24	36	..	48
4.190	33	42	24	45	4.588	39	30	18	51	5.014	24	27	22	39
4.196	27	33	20	39	4.602	27	22	18	48	5.025	19	55	48	33

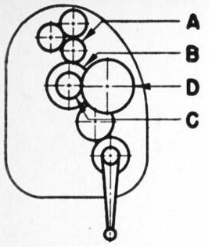


TABLE OF LEADS (5.033 to 6.291)

Lead of Spiral in Inches	A	B	C	D	Lead of Spiral in Inches	A	B	C	D	Lead of Spiral in Inches	A	B	C	D
5.033	42	36	22	51	**5.440**	33	39	27	42	**5.882**	30	36	..	51
5.038	42	33	19	48	**5.444**	42	36	21	45	**5.887**	48	33	17	42
5.042	33	30	22	48	**5.455**	36	33	24	48	**5.893**	33	36	27	42
5.048	45	39	21	48	**5.469**	45	36	21	48	**5.903**	55	33	17	48
5.056	39	36	21	45	**5.481**	27	24	19	39	**5.911**	42	30	19	45
5.065	39	33	18	42	**5.489**	39	30	19	45	**5.921**	30	19	18	48
5.068	21	51	48	39	**5.495**	45	39	20	42	**5.926**	24	27	24	36
5.077	33	39	27	45	**5.500**	33	36	27	45	**5.934**	36	39	27	42
5.080	45	33	19	51	**5.510**	27	21	18	42	**5.939**	42	33	21	45
5.085	42	36	17	39	**5.515**	39	33	21	45	**5.948**	39	27	21	51
5.091	36	33	21	45	**5.527**	19	55	48	30	**5.954**	33	27	19	39
5.098	39	36	24	51	**5.538**	36	39	27	45	**5.961**	48	30	19	51
5.104	42	36	21	48	**5.546**	33	21	18	51	**5.966**	45	33	21	48
5.114	30	33	27	48	**5.552**	27	22	19	42	**5.975**	33	27	22	45
5.123	33	24	19	51	**5.556**	20	39	..	36	**5.983**	42	36	20	39
5.128	20	42	..	39	**5.561**	39	33	24	51	**5.989**	42	33	24	51
5.135	20	51	55	42	**5.568**	42	33	21	48	**5.994**	51	39	22	48
5.143	36	42	27	45	**5.573**	30	19	18	51	**6.000**	27	39	..	45
5.147	45	36	21	51	**5.581**	39	33	17	36	**6.010**	42	33	17	36
5.152	17	45	..	33	**5.587**	22	45	48	42	**6.019**	39	27	20	48
5.156	33	36	27	48	**5.594**	30	33	24	39	**6.027**	27	42	45	48
5.160	33	27	19	45	**5.600**	36	30	21	45	**6.032**	48	36	19	42
5.170	39	33	21	48	**5.608**	39	30	22	51	**6.039**	42	30	22	51
5.176	51	39	19	48	**5.615**	45	33	21	51	**6.044**	33	39	30	42
5.185	42	36	20	45	**5.625**	27	36	..	48	**6.050**	36	21	18	51
5.192	36	39	27	48	**5.630**	48	36	19	45	**6.054**	39	24	19	51
5.195	30	33	24	42	**5.641**	22	42	..	39	**6.058**	27	24	21	39
5.200	39	30	18	45	**5.647**	36	30	24	51	**6.061**	20	42	..	33
5.208	45	36	20	48	**5.657**	42	33	20	45	**6.067**	39	30	21	45
5.216	42	30	19	51	**5.664**	39	27	20	51	**6.071**	45	30	17	42
5.223	27	48	39	42	**5.675**	39	36	22	42	**6.090**	45	36	19	39
5.229	48	36	20	51	**5.682**	45	33	20	48	**6.095**	24	45	48	42
5.238	22	45	..	42	**5.687**	39	30	21	48	**6.100**	42	27	20	51
5.241	42	33	21	51	**5.692**	55	36	19	51	**6.107**	27	20	19	42
5.250	27	30	21	36	**5.698**	30	27	20	39	**6.111**	22	42	..	36
5.255	17	55	51	30	**5.704**	42	36	22	45	**6.118**	39	30	24	51
5.260	27	22	18	42	**5.714**	24	39	..	42	**6.125**	42	30	21	48
5.265	42	39	22	45	**5.718**	39	27	19	48	**6.130**	33	19	18	51
5.272	33	27	22	51	**5.727**	27	22	21	45	**6.136**	36	33	27	48
5.278	19	42	..	36	**5.735**	39	24	18	51	**6.141**	48	33	19	45
5.288	33	39	30	48	**5.744**	42	39	24	45	**6.154**	24	42	..	39
5.294	27	36	..	51	**5.752**	33	27	24	51	**6.162**	33	21	20	51
5.303	42	33	20	48	**5.758**	19	42	..	33	**6.169**	45	33	19	42
5.312	51	36	18	48	**5.762**	33	30	22	42	**6.176**	36	24	21	51
5.322	30	21	19	51	**5.769**	36	39	30	48	**6.182**	51	33	18	45
5.333	24	39	..	45	**5.775**	36	33	27	51	**6.190**	39	36	24	42
5.339	19	55	51	33	**5.782**	30	21	17	42	**6.198**	51	36	21	48
5.347	42	36	22	48	**5.789**	33	19	17	51	**6.205**	33	30	22	39
5.353	39	30	21	51	**5.795**	51	33	18	48	**6.209**	45	27	19	51
5.359	33	30	19	39	**5.804**	30	42	39	48	**6.222**	42	36	24	45
5.369	27	22	21	48	**5.807**	21	51	55	39	**6.231**	39	27	22	51
5.378	33	30	22	45	**5.816**	27	21	19	42	**6.237**	39	33	19	36
5.385	21	42	..	39	**5.820**	30	27	22	42	**6.250**	30	36	..	48
5.392	45	36	22	51	**5.824**	33	30	27	51	**6.257**	39	33	27	51
5.398	45	33	19	48	**5.833**	21	39	..	36	**6.268**	30	27	22	39
5.413	30	27	19	39	**5.844**	30	33	27	42	**6.275**	48	33	22	51
5.419	48	33	19	51	**5.854**	33	21	19	51	**6.282**	42	36	21	39
5.429	36	30	19	42	**5.864**	30	27	19	36	**6.286**	33	21	18	45
5.432	30	27	22	45	**5.874**	36	33	21	39	**6.291**	21	51	55	36

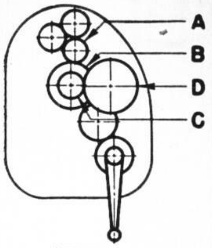


TABLE OF LEADS (6.296 to 7.483)

Lead of Spiral in Inches	A	B	C	D	Lead of Spiral in Inches	A	B	C	D	Lead of Spiral in Inches	A	B	C	D
6.296	17	45	..	27	**6.699**	33	24	19	39	**7.059**	45	30	24	51
6.303	39	33	24	45	**6.710**	42	27	22	51	**7.062**	39	27	22	45
6.316	36	19	17	51	**6.713**	36	33	24	39	**7.071**	33	30	27	44
6.319	39	27	21	48	**6.717**	42	33	19	36	**7.083**	17	45	..	24
6.333	19	42	..	30	**6.722**	33	24	22	45	**7.086**	48	33	19	39
6.340	48	33	17	39	**6.729**	51	30	19	48	**7.091**	39	33	27	45
6.346	33	36	27	39	**6.734**	30	27	20	33	**7.105**	36	19	18	48
6.349	48	36	20	42	**6.738**	42	33	27	51	**7.112**	42	22	19	51
6.353	36	30	27	51	**6.741**	39	27	21	45	**7.125**	36	20	19	48
6.356	39	30	22	45	**6.746**	55	33	17	42	**7.130**	42	27	22	48
6.364	21	42	..	33	**6.750**	36	30	27	48	**7.136**	51	27	17	45
6.375	51	30	18	48	**6.756**	48	30	19	45	**7.143**	30	39	..	42
6.387	36	21	19	51	**6.761**	51	33	21	48	**7.152**	33	19	21	51
6.393	22	45	51	39	**6.769**	33	30	24	39	**7.159**	42	33	27	48
6.400	36	30	24	45	**6.774**	60	33	19	51	**7.175**	39	22	17	42
6.405	42	27	21	51	**6.779**	33	21	22	51	**7.179**	42	36	24	39
6.410	45	36	20	39	**6.786**	45	30	19	42	**7.190**	33	27	30	51
6.417	36	33	30	51	**6.790**	30	27	22	36	**7.200**	36	30	27	45
6.420	39	27	20	45	**6.797**	39	27	24	51	**7.206**	42	24	21	51
6.429	27	39	..	42	**6.806**	42	27	21	48	**7.212**	51	33	21	45
6.439	45	33	17	36	**6.810**	39	30	22	42	**7.222**	39	27	24	48
6.447	22	42	48	39	**6.818**	36	33	30	48	**7.232**	33	17	19	51
6.451	33	27	19	36	**6.821**	42	30	19	39	**7.240**	30	39	48	51
6.462	42	39	27	45	**6.830**	55	30	19	51	**7.245**	39	19	18	51
6.465	48	33	20	45	**6.838**	48	36	20	39	**7.253**	36	39	33	42
6.471	33	36	..	51	**6.845**	24	51	48	33	**7.259**	42	27	21	45
6.477	36	22	19	48	**6.853**	42	33	21	39	**7.265**	45	27	17	39
6.481	42	27	20	48	**6.857**	36	30	24	42	**7.273**	24	42	..	33
6.490	27	39	45	48	**6.863**	45	27	21	51	**7.279**	33	24	27	51
6.494	45	33	20	42	**6.869**	48	33	17	36	**7.283**	39	21	20	51
6.500	39	30	24	48	**6.875**	33	30	..	48	**7.286**	51	30	18	42
6.513	33	19	18	48	**6.878**	39	27	20	42	**7.292**	45	27	21	48
6.519	33	27	24	45	**6.882**	39	30	27	51	**7.299**	39	22	21	51
6.525	51	33	19	45	**6.894**	39	33	21	36	**7.308**	45	30	19	39
6.531	33	20	19	48	**6.902**	48	30	22	51	**7.313**	39	20	18	48
6.536	45	27	20	51	**6.908**	30	19	21	48	**7.320**	42	27	24	51
6.545	36	33	27	45	**6.914**	42	27	20	45	**7.326**	30	21	20	39
6.555	39	21	18	51	**6.919**	39	21	19	51	**7.333**	33	36	..	45
6.563	36	24	21	48	**6.923**	27	42	..	39	**7.341**	19	55	51	24
6.568	42	27	19	45	**6.926**	48	33	20	42	**7.347**	27	21	24	42
6.577	39	21	17	48	**6.933**	39	30	24	45	**7.353**	45	24	20	51
6.581	42	36	22	39	**6.939**	36	21	17	42	**7.368**	30	19	21	45
6.588	42	30	24	51	**6.944**	45	27	20	48	**7.385**	36	30	24	39
6.593	45	39	24	42	**6.947**	33	19	18	45	**7.389**	42	24	19	45
6.600	33	30	27	45	**6.952**	39	33	30	51	**7.395**	33	21	24	51
6.608	27	22	21	39	**6.955**	18	55	51	24	**7.403**	36	22	19	42
6.611	42	24	17	45	**6.960**	30	21	19	39	**7.407**	20	45	..	27
6.618	30	24	27	51	**6.964**	39	36	27	42	**7.412**	42	30	27	51
6.623	51	33	18	42	**6.968**	33	39	42	51	**7.418**	45	39	27	42
6.632	27	19	21	45	**6.972**	48	27	20	51	**7.424**	42	33	21	36
6.635	33	21	19	45	**6.984**	48	36	22	42	**7.429**	39	30	24	42
6.643	45	33	19	39	**6.993**	45	33	20	39	**7.438**	51	30	21	48
6.648	39	33	27	48	**7.000**	21	42	..	30	**7.444**	33	19	18	42
6.667	30	36	..	45	**7.010**	39	24	22	51	**7.451**	42	21	19	51
6.679	33	20	17	42	**7.013**	36	33	27	42	**7.459**	48	33	20	39
6.684	55	36	21	48	**7.018**	30	19	20	45	**7.464**	33	20	19	42
6.687	36	19	18	51	**7.030**	33	19	17	42	**7.469**	33	27	22	36
6.691	39	24	21	51	**7.037**	19	45	..	27	**7.474**	36	17	18	51
6.696	30	42	45	48	**7.051**	30	24	22	39	**7.483**	30	21	22	42

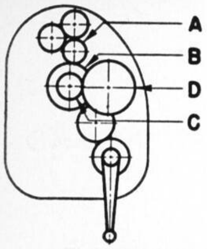


TABLE OF LEADS (7.487 to 8.766)

Lead of Spiral in Inches	A	B	C	D	Lead of Spiral in Inches	A	B	C	D	Lead of Spiral in Inches	A	B	C	D
7.487	42	33	30	51	**7.889**	36	17	19	51	**8.319**	33	21	27	51
7.492	33	19	22	51	**7.897**	42	30	22	39	**8.322**	51	33	21	39
7.500	36	33	..	48	**7.901**	48	27	20	45	**8.333**	30	39	..	36
7.506	48	27	19	45	**7.908**	33	18	22	51	**8.342**	39	22	24	51
7.517	39	21	17	42	**7.912**	48	39	27	42	**8.352**	42	22	21	48
7.521	48	36	22	39	**7.917**	19	42	..	24	**8.357**	39	30	27	42
7.529	51	33	19	39	**7.933**	51	30	21	45	**8.366**	48	27	24	51
7.538	42	30	21	39	**7.944**	39	36	33	45	**8.374**	33	17	22	51
7.549	42	24	22	51	**7.955**	42	33	30	48	**8.381**	48	30	22	42
7.552	36	33	27	39	**7.964**	33	39	48	51	**8.388**	55	27	21	51
7.557	42	22	19	48	**7.972**	36	22	19	39	**8.392**	36	33	30	39
7.563	33	20	22	48	**7.977**	42	27	20	39	**8.400**	42	30	27	45
7.566	39	27	22	42	**7.983**	45	21	19	51	**8.403**	45	21	20	51
7.571	33	19	17	39	**7.988**	55	27	20	51	**8.412**	39	30	33	51
7.576	60	33	20	48	**7.993**	33	17	21	51	**8.422**	45	22	21	51
7.583	39	30	21	36	**8.000**	36	33	..	45	**8.426**	39	27	21	36
7.589	55	27	19	51	**8.011**	39	21	22	51	**8.438**	36	24	27	48
7.597	39	33	27	42	**8.016**	33	19	18	39	**8.444**	48	24	19	45
7.600	36	20	19	45	**8.021**	42	24	22	48	**8.452**	39	19	21	51
7.605	42	27	22	45	**8.028**	51	24	17	45	**8.462**	33	36	..	39
7.612	33	17	20	51	**8.036**	45	36	27	42	**8.471**	36	17	18	45
7.615	33	30	27	39	**8.042**	48	27	19	42	**8.482**	45	24	19	42
7.619	48	30	20	42	**8.050**	39	19	20	51	**8.488**	55	27	20	48
7.623	39	27	19	36	**8.059**	30	21	22	39	**8.493**	33	17	21	48
7.628	42	24	17	39	**8.063**	55	27	19	48	**8.497**	39	27	30	51
7.636	36	22	21	45	**8.067**	36	21	24	51	**8.502**	30	19	21	39
7.639	33	27	30	48	**8.072**	39	18	19	51	**8.512**	39	24	22	42
7.646	51	27	17	42	**8.077**	45	30	21	39	**8.515**	48	21	19	51
7.656	42	24	21	48	**8.081**	60	33	20	45	**8.523**	45	22	20	48
7.669	48	27	22	51	**8.088**	33	24	30	51	**8.531**	39	20	21	48
7.677	36	27	19	33	**8.095**	17	45	..	21	**8.538**	55	24	19	51
7.684	33	17	19	48	**8.105**	33	19	21	45	**8.545**	51	27	19	42
7.692	30	36	..	39	**8.114**	21	55	51	24	**8.553**	39	19	20	48
7.697	39	19	18	48	**8.120**	55	33	19	39	**8.556**	42	30	22	36
7.700	33	20	21	45	**8.128**	48	22	19	51	**8.571**	36	33	..	42
7.704	39	27	24	45	**8.143**	36	20	19	42	**8.576**	39	24	19	36
7.714	36	30	27	42	**8.148**	22	42	..	27	**8.594**	33	24	30	48
7.721	45	24	21	51	**8.157**	51	33	19	36	**8.603**	39	24	27	51
7.727	17	45	..	22	**8.163**	30	21	24	42	**8.615**	42	30	24	39
7.734	33	24	27	48	**8.167**	42	24	21	45	**8.627**	42	21	22	51
7.738	39	36	30	42	**8.173**	45	24	17	39	**8.636**	19	45	..	22
7.741	55	30	19	45	**8.182**	27	39	..	33	**8.643**	33	20	22	42
7.749	48	27	17	39	**8.196**	33	17	19	45	**8.654**	45	36	27	39
7.758	48	33	24	45	**8.205**	48	36	24	39	**8.661**	48	27	19	39
7.765	36	30	33	51	**8.211**	39	19	18	45	**8.667**	39	33	..	45
7.778	21	42	..	27	**8.231**	33	21	22	42	**8.673**	45	21	17	42
7.792	51	30	22	48	**8.235**	48	24	21	51	**8.684**	33	19	24	48
7.800	39	30	27	45	**8.242**	51	33	24	45	**8.693**	51	22	18	48
7.813	45	24	20	48	**8.250**	33	20	24	48	**8.708**	33	20	19	36
7.822	48	30	22	45	**8.254**	39	27	24	42	**8.715**	60	27	20	51
7.829	42	19	17	48	**8.259**	36	19	17	39	**8.720**	36	17	21	51
7.832	42	33	24	39	**8.264**	51	27	21	48	**8.727**	36	30	24	33
7.841	39	21	19	45	**8.273**	39	30	21	33	**8.730**	33	27	30	42
7.846	51	30	18	39	**8.282**	51	30	19	39	**8.739**	39	21	24	51
7.857	33	36	..	42	**8.289**	36	19	21	48	**8.745**	27	19	24	39
7.861	42	22	21	51	**8.296**	42	27	24	45	**8.750**	21	45	..	24
7.870	45	27	17	36	**8.305**	36	17	20	51	**8.754**	39	27	20	33
7.875	42	30	27	48	**8.308**	36	30	27	39	**8.758**	51	22	17	45
7.879	39	33	30	45	**8.312**	48	33	24	42	**8.766**	45	33	27	42

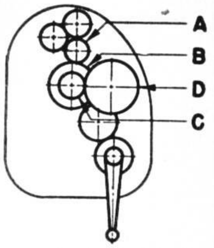


TABLE OF LEADS (8.769 to 10.094)

Lead of Spiral in Inches	A	B	C	D
8.769	36	20	19	39
8.775	42	27	22	39
8.782	33	17	19	42
8.787	55	27	22	51
8.791	30	21	24	39
8.796	60	27	19	48
8.800	33	20	24	45
8.811	42	33	27	39
8.815	51	27	21	45
8.821	39	20	19	42
8.827	39	27	22	36
8.831	48	22	17	42
8.839	33	24	27	42
8.844	39	21	20	42
8.854	55	22	17	48
8.864	39	33	36	48
8.867	42	20	19	45
8.882	45	19	18	48
8.889	24	42	..	27
8.897	33	17	22	48
8.905	51	30	22	42
8.909	42	22	21	45
8.916	36	19	24	51
8.922	39	18	21	51
8.929	45	24	20	42
8.932	55	30	19	39
8.938	39	20	22	48
8.941	36	17	19	45
8.947	17	45	..	19
8.951	48	33	24	39
8.956	42	27	19	33
8.964	48	21	20	51
8.972	51	24	19	45
8.980	39	19	21	48
8.990	33	39	51	48
9.000	27	42	..	30
9.015	42	22	17	36
9.023	30	19	24	42
9.031	51	20	17	48
9.048	19	45	..	21
9.053	55	27	20	45
9.059	42	30	33	51
9.066	27	42	55	39
9.071	55	24	19	48
9.076	36	21	27	51
9.081	39	17	19	48
9.091	30	36	..	33
9.098	33	19	22	42
9.102	42	19	21	51
9.107	51	36	27	42
9.117	48	27	20	39
9.123	39	19	20	45
9.135	45	24	19	39
9.141	39	24	27	48
9.148	39	18	19	45
9.150	42	27	30	51
9.154	51	30	21	39
9.167	33	39	..	36
9.176	39	30	36	51
9.184	30	21	27	42
9.192	39	27	21	33
9.202	51	27	19	39
9.205	36	22	27	48
9.211	42	19	20	48
9.215	55	27	19	42
9.231	36	33	..	39
9.236	42	24	19	36
9.244	45	21	22	51
9.253	45	22	19	42
9.259	60	27	20	48
9.273	51	33	27	45
9.281	33	20	27	48
9.288	45	19	20	51
9.297	51	24	21	48
9.301	42	22	19	39
9.308	33	20	22	39
9.314	60	24	19	51
9.333	42	30	24	36
9.341	45	21	17	39
9.346	39	27	33	51
9.351	48	33	27	42
9.356	39	24	19	33
9.375	36	24	30	48
9.385	39	22	27	51
9.402	33	27	30	39
9.408	39	19	22	48
9.412	42	21	24	51
9.421	36	22	19	33
9.429	33	21	27	45
9.436	55	24	21	51
9.441	45	33	27	39
9.446	39	17	21	51
9.455	39	30	24	33
9.474	18	45	..	19
9.481	48	27	24	45
9.490	33	17	22	45
9.500	19	45	..	20
9.506	55	27	21	45
9.510	51	33	24	39
9.519	33	24	27	39
9.524	20	45	..	21
9.533	39	20	22	45
9.536	42	19	22	51
9.545	21	45	..	22
9.549	55	24	20	48
9.559	39	24	30	51
9.563	51	20	18	48
9.573	42	27	24	39
9.579	39	19	21	45
9.586	45	19	17	42
9.590	51	30	22	39
9.596	45	27	19	33
9.600	48	30	27	45
9.603	55	30	22	42
9.608	42	18	21	51
9.613	51	24	19	42
9.619	55	27	17	36
9.625	42	20	22	48
9.630	39	27	24	36
9.636	42	19	17	39
9.643	36	24	27	42
9.651	48	21	19	45
9.659	39	19	24	51
9.670	33	21	24	39
9.676	55	24	19	45
9.686	39	17	19	45
9.692	42	30	27	39
9.700	55	27	20	42
9.706	36	24	33	51
9.714	51	21	18	45
9.722	45	27	21	36
9.728	39	21	22	42
9.740	45	33	30	42
9.744	48	24	19	39
9.750	39	30	27	36
9.757	55	21	19	51
9.770	33	19	27	48
9.778	55	30	24	45
9.788	51	30	19	33
9.796	36	21	24	42
9.800	42	20	21	45
9.808	51	24	18	39
9.818	36	20	18	33
9.825	42	19	20	45
9.832	39	21	27	51
9.844	42	24	27	48
9.852	42	18	19	45
9.860	48	21	22	51
9.868	45	19	20	48
9.872	55	30	21	39
9.877	48	27	20	36
9.882	36	17	21	45
9.886	55	24	22	51
9.890	30	21	27	39
9.894	51	27	22	42
9.900	33	20	27	45
9.907	48	19	20	51
9.917	30	22	24	33
9.926	45	24	27	51
9.931	39	24	22	36
9.935	51	33	27	42
9.955	33	17	20	39
9.959	55	27	22	45
9.965	36	17	24	51
9.969	51	27	19	36
9.972	39	22	27	48
9.989	55	24	17	39
10.000	24	45	..	24
10.026	55	24	21	48
10.031	36	19	27	51
10.037	39	17	21	48
10.053	60	27	19	42
10.065	42	27	33	51
10.070	36	22	24	39
10.076	42	22	19	36
10.084	45	21	24	51
10.094	51	20	19	48

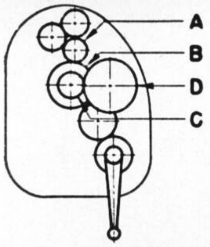


TABLE OF LEADS (10.096 to 11.692)

Lead of Spiral in Inches	A	B	C	D	Lead of Spiral in Inches	A	B	C	D	Lead of Spiral in Inches	A	B	C	D
10.096	45	24	21	39	**10.625**	51	24	18	36	**11.156**	51	20	21	48
10.102	33	21	27	42	**10.636**	39	22	27	45	**11.165**	55	24	19	39
10.107	42	22	27	51	**10.644**	60	21	19	51	**11.172**	39	24	33	48
10.119	55	22	17	42	**10.655**	51	27	22	39	**11.176**	19	45	..	17
10.125	36	20	27	48	**10.658**	36	19	27	48	**11.184**	45	19	17	36
10.133	48	20	19	45	**10.670**	55	27	22	42	**11.189**	48	33	30	39
10.142	51	22	21	48	**10.688**	33	19	24	39	**11.200**	42	30	36	45
10.150	30	19	27	42	**10.694**	42	27	33	48	**11.204**	55	24	22	45
10.156	39	24	30	48	**10.699**	51	22	18	39	**11.211**	36	17	27	51
10.160	60	22	19	51	**10.706**	42	30	39	51	**11.216**	39	17	22	45
10.168	33	17	22	42	**10.714**	33	22	30	42	**11.224**	45	21	22	42
10.173	42	17	21	51	**10.739**	42	22	27	48	**11.230**	42	22	30	51
10.185	55	27	24	48	**10.744**	39	22	20	33	**11.250**	27	42	..	24
10.200	51	30	27	45	**10.751**	55	27	19	36	**11.259**	48	18	19	45
10.208	42	24	21	36	**10.756**	48	21	24	51	**11.278**	45	19	20	42
10.217	45	19	22	51	**10.769**	42	33	..	39	**11.282**	55	30	24	39
10.227	36	22	30	48	**10.774**	48	27	20	33	**11.294**	51	22	19	39
10.236	48	27	19	33	**10.784**	45	27	33	51	**11.298**	55	21	22	51
10.252	55	19	17	48	**10.794**	51	27	24	42	**11.308**	42	20	21	39
10.263	39	19	24	48	**10.800**	36	20	27	45	**11.313**	42	27	24	33
10.271	55	21	20	51	**10.809**	42	17	21	48	**11.317**	55	27	20	36
10.280	42	22	21	39	**10.818**	51	22	21	45	**11.324**	42	24	33	51
10.286	48	30	27	42	**10.822**	55	18	17	48	**11.329**	36	22	27	39
10.294	55	22	21	51	**10.827**	36	19	24	42	**11.336**	42	19	20	39
10.303	51	33	24	36	**10.833**	39	33	..	36	**11.345**	45	21	27	51
10.313	45	30	33	48	**10.855**	45	19	22	48	**11.352**	55	19	20	51
10.324	45	19	17	39	**10.860**	30	17	24	39	**11.364**	45	33	30	36
10.340	48	21	19	42	**10.867**	39	19	27	51	**11.368**	36	19	27	45
10.353	51	24	19	39	**10.875**	51	27	19	33	**11.375**	42	30	39	48
10.362	45	19	21	48	**10.884**	48	21	20	42	**11.383**	55	18	19	51
10.370	42	27	24	36	**10.889**	42	18	21	45	**11.396**	60	27	20	39
10.378	39	17	19	42	**10.900**	45	17	21	51	**11.407**	42	27	33	45
10.385	45	30	27	39	**10.909**	36	39	..	33	**11.416**	55	21	17	39
10.390	48	22	20	42	**10.913**	55	24	20	42	**11.423**	33	20	27	39
10.400	39	30	36	45	**10.919**	33	17	27	48	**11.429**	24	45	..	21
10.408	51	21	18	42	**10.924**	39	21	30	51	**11.435**	39	18	19	36
10.413	36	22	21	33	**10.931**	30	19	27	39	**11.442**	51	24	21	39
10.421	33	19	27	45	**10.940**	48	27	24	39	**11.455**	42	22	27	45
10.431	42	17	19	45	**10.950**	33	17	22	39	**11.471**	39	17	24	48
10.440	45	21	19	39	**10.962**	45	20	19	39	**11.483**	36	19	20	33
10.446	55	27	20	39	**10.969**	55	27	21	39	**11.491**	55	27	22	39
10.452	33	17	21	39	**10.980**	42	18	24	51	**11.503**	48	18	22	51
10.462	48	20	17	39	**10.986**	51	21	19	42	**11.515**	60	22	19	45
10.476	22	45	..	21	**10.992**	42	22	19	33	**11.529**	42	17	21	45
10.490	45	33	30	39	**11.000**	33	42	..	30	**11.538**	45	30	..	39
10.500	21	45	..	20	**11.014**	45	22	21	39	**11.546**	39	19	27	48
10.505	39	27	24	33	**11.020**	36	21	27	42	**11.556**	39	27	36	45
10.515	39	24	33	51	**11.029**	45	24	30	51	**11.570**	42	22	20	33
10.519	36	22	27	42	**11.039**	51	33	30	42	**11.579**	22	45	..	19
10.526	20	45	..	19	**11.053**	21	45	..	19	**11.591**	51	22	21	42
10.547	45	24	27	48	**11.058**	55	21	19	45	**11.607**	39	24	30	42
10.556	19	45	..	18	**11.073**	48	17	20	51	**11.611**	55	20	19	45
10.577	33	24	30	39	**11.080**	39	22	30	48	**11.624**	51	27	24	39
10.582	60	27	20	42	**11.092**	36	21	33	51	**11.636**	48	22	24	45
10.588	18	45	..	17	**11.111**	30	39	..	27	**11.647**	33	17	27	45
10.593	39	27	33	45	**11.123**	39	33	48	51	**11.660**	36	19	24	39
10.601	55	21	17	42	**11.131**	51	24	22	42	**11.667**	42	33	..	36
10.607	33	20	27	42	**11.136**	42	22	21	36	**11.688**	60	33	27	42
10.614	33	19	22	36	**11.146**	36	19	30	51	**11.692**	48	20	19	39

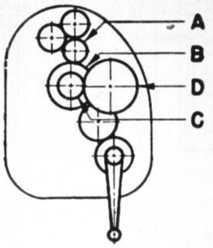


TABLE OF LEADS (11.703 to 13.303)

Lead of Spiral in Inches	A	B	C	D	Lead of Spiral in Inches	A	B	C	D	Lead of Spiral in Inches	A	B	C	D
11.703	42	19	27	51	**12.217**	45	17	18	39	**12.745**	45	27	39	51
11.719	45	24	30	48	**12.222**	33	39	..	27	**12.750**	51	30	27	36
11.729	39	19	24	42	**12.235**	51	22	19	36	**12.759**	55	21	19	39
11.733	48	20	22	45	**12.245**	45	21	24	42	**12.768**	39	24	33	42
11.743	51	19	21	48	**12.250**	42	20	21	36	**12.773**	48	17	19	42
11.748	42	22	24	39	**12.273**	27	42	..	22	**12.784**	45	22	30	48
11.752	55	24	20	39	**12.281**	42	19	20	36	**12.795**	60	27	19	33
11.765	20	48	..	17	**12.303**	51	19	22	48	**12.800**	48	20	24	45
11.769	51	30	27	39	**12.308**	42	21	24	39	**12.806**	55	17	19	48
11.777	45	22	19	33	**12.316**	39	19	27	45	**12.817**	51	21	19	36
11.789	42	19	24	45	**12.325**	55	21	24	51	**12.821**	55	22	20	39
11.806	55	22	17	36	**12.338**	60	22	19	42	**12.829**	39	19	30	48
11.813	42	20	27	48	**12.346**	60	27	20	36	**12.834**	48	22	30	51
11.818	39	36	..	33	**12.353**	21	45	..	17	**12.857**	27	45	..	21
11.831	51	21	19	39	**12.364**	51	22	24	45	**12.866**	55	19	20	45
11.842	45	19	24	48	**12.375**	33	24	27	30	**12.879**	51	33	30	36
11.846	42	30	33	39	**12.381**	39	27	36	42	**12.891**	45	24	33	48
11.852	48	27	24	36	**12.389**	51	19	18	39	**12.896**	45	17	19	39
11.863	33	17	22	36	**12.397**	45	22	20	33	**12.904**	39	17	27	48
11.868	36	21	27	39	**12.409**	39	22	21	30	**12.919**	30	19	27	33
11.875	51	17	19	48	**12.418**	60	18	19	51	**12.923**	42	20	24	39
11.883	55	27	21	36	**12.423**	51	20	19	39	**12.929**	48	27	24	33
11.889	48	19	24	51	**12.434**	42	19	27	48	**12.941**	22	45	..	17
11.895	42	27	39	51	**12.440**	55	20	19	42	**12.952**	51	21	24	45
11.900	51	20	21	45	**12.449**	55	27	22	36	**12.963**	55	27	21	33
11.905	45	27	30	42	**12.457**	45	17	24	51	**12.981**	45	24	27	39
11.912	36	17	27	48	**12.462**	36	20	27	39	**12.991**	48	18	19	39
11.917	39	30	33	36	**12.467**	51	20	22	45	**13.000**	39	36	..	30
11.922	48	17	19	45	**12.472**	55	21	20	42	**13.017**	45	22	21	33
11.932	42	22	30	48	**12.479**	33	17	27	42	**13.026**	36	19	33	48
11.939	39	21	27	42	**12.487**	55	19	22	51	**13.032**	36	17	24	39
11.946	33	17	24	39	**12.500**	45	33	..	36	**13.040**	51	22	27	48
11.953	51	24	27	48	**12.513**	39	22	36	51	**13.061**	48	21	24	42
11.963	51	18	19	45	**12.526**	51	19	21	45	**13.072**	60	18	20	51
11.973	48	21	22	42	**12.536**	55	27	24	39	**13.080**	42	17	27	51
11.983	55	18	20	51	**12.544**	39	19	22	36	**13.095**	45	27	33	42
11.987	51	24	22	39	**12.549**	48	18	24	51	**13.109**	39	21	36	51
12.000	36	39	..	30	**12.557**	39	33	51	48	**13.117**	36	19	27	39
12.004	55	21	22	48	**12.564**	42	18	21	39	**13.125**	42	24	36	48
12.017	39	21	33	51	**12.571**	36	21	33	45	**13.131**	39	27	30	33
12.024	33	19	27	39	**12.582**	55	18	21	51	**13.149**	45	22	27	42
12.031	42	24	33	48	**12.587**	45	33	36	39	**13.162**	42	27	33	39
12.037	39	27	30	36	**12.593**	51	27	24	36	**13.176**	42	17	24	45
12.042	51	20	17	36	**12.600**	42	20	27	45	**13.181**	55	18	22	51
12.053	55	17	19	51	**12.606**	39	33	48	45	**13.187**	36	21	30	39
12.057	36	19	21	33	**12.618**	55	19	17	39	**13.195**	39	19	27	42
12.063	60	21	19	45	**12.632**	24	45	..	19	**13.200**	36	20	33	45
12.074	39	19	30	51	**12.639**	42	27	39	48	**13.209**	39	17	19	33
12.088	33	21	30	39	**12.656**	45	20	27	48	**13.217**	42	22	27	39
12.095	55	24	19	36	**12.662**	39	22	30	42	**13.223**	48	22	20	33
12.101	48	21	27	51	**12.667**	60	20	19	45	**13.233**	48	19	22	42
12.108	39	17	19	36	**12.675**	51	19	17	36	**13.241**	39	27	33	36
12.115	42	24	27	39	**12.687**	55	17	20	51	**13.247**	51	22	24	42
12.121	60	22	20	45	**12.692**	45	30	33	39	**13.263**	42	19	27	45
12.133	42	30	39	45	**12.698**	48	27	30	42	**13.268**	55	19	22	48
12.149	42	22	21	33	**12.706**	36	17	27	45	**13.281**	51	24	30	48
12.179	60	24	19	39	**12.721**	51	21	22	42	**13.287**	48	17	24	51
12.188	39	22	33	48	**12.727**	42	36	..	33	**13.295**	39	22	36	48
12.201	45	19	17	33	**12.731**	55	24	20	36	**13.303**	42	17	21	39

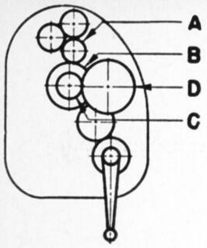


TABLE OF LEADS (13.322 to 15.231)

Lead of Spiral in Inches	A	B	C	D	Lead of Spiral in Inches	A	B	C	D	Lead of Spiral in Inches	A	B	C	D
13.322	45	19	27	48	**13.929**	39	22	33	42	**14.592**	39	21	33	42
13.333	48	33	..	36	**13.937**	42	17	22	39	**14.599**	42	22	39	51
13.347	51	22	19	33	**13.956**	55	17	22	51	**14.609**	51	24	33	48
13.357	51	20	22	42	**13.971**	60	17	19	48	**14.615**	60	20	19	39
13.368	55	24	21	36	**13.986**	60	33	30	39	**14.625**	39	30	27	24
13.375	48	19	27	51	**14.000**	42	36	..	30	**14.636**	55	17	19	42
13.382	42	24	39	51	**14.005**	55	24	22	36	**14.641**	51	19	18	33
13.388	36	22	27	33	**14.014**	45	17	27	51	**14.652**	60	21	20	39
13.397	55	20	19	39	**14.020**	39	18	33	51	**14.661**	36	17	27	39
13.406	39	20	33	48	**14.026**	48	22	27	42	**14.667**	55	20	24	45
13.421	51	19	24	48	**14.035**	60	19	20	45	**14.682**	51	20	19	33
13.431	55	21	20	39	**14.060**	51	19	22	42	**14.694**	48	21	27	42
13.439	33	17	27	39	**14.066**	48	21	24	39	**14.706**	45	18	30	51
13.445	48	21	30	51	**14.074**	60	18	19	45	**14.712**	51	24	27	39
13.458	51	20	19	36	**14.103**	60	24	22	39	**14.727**	36	22	27	30
13.468	60	27	20	33	**14.112**	39	19	33	48	**14.737**	42	19	30	45
13.474	48	19	24	45	**14.118**	24	48	..	17	**14.748**	39	17	27	42
13.481	42	27	39	45	**14.141**	42	27	30	33	**14.752**	51	22	21	33
13.492	51	27	30	42	**14.152**	55	19	22	45	**14.769**	48	20	24	39
13.500	27	42	..	20	**14.161**	45	22	27	39	**14.774**	55	21	22	39
13.509	42	19	22	36	**14.167**	51	24	30	45	**14.790**	48	21	33	51
13.523	51	24	21	33	**14.182**	39	30	36	33	**14.803**	45	19	30	48
13.534	36	19	30	42	**14.211**	27	42	..	19	**14.808**	42	24	33	39
13.542	45	27	39	48	**14.219**	42	24	39	48	**14.815**	55	27	24	33
13.571	60	20	19	42	**14.225**	42	17	19	33	**14.824**	42	17	27	45
13.580	55	27	24	36	**14.251**	48	19	22	39	**14.835**	45	21	27	39
13.600	51	20	24	45	**14.259**	42	27	33	36	**14.841**	51	27	33	42
13.611	42	18	21	36	**14.266**	51	22	24	39	**14.850**	33	20	27	30
13.622	55	19	24	51	**14.286**	30	39	..	21	**14.861**	48	19	30	51
13.636	45	36	..	33	**14.300**	39	20	33	45	**14.875**	51	20	21	36
13.660	55	17	19	45	**14.316**	51	19	24	45	**14.886**	55	18	19	39
13.670	55	19	17	36	**14.338**	45	24	39	51	**14.890**	45	17	27	48
13.675	48	27	30	39	**14.344**	51	20	27	48	**14.896**	39	36	33	24
13.684	39	19	30	45	**14.351**	39	33	51	42	**14.903**	51	22	27	42
13.700	51	21	22	39	**14.359**	42	27	36	39	**14.928**	39	19	24	33
13.714	48	21	27	45	**14.379**	55	18	24	51	**14.938**	55	27	22	30
13.719	55	21	22	42	**14.385**	51	30	33	39	**14.945**	51	21	24	39
13.725	45	27	42	51	**14.394**	60	24	19	33	**14.954**	51	18	19	36
13.731	51	20	21	39	**14.400**	48	20	27	45	**14.966**	55	21	24	42
13.737	51	27	24	33	**14.405**	55	20	22	42	**14.973**	42	17	20	33
13.750	33	42	..	24	**14.412**	42	17	21	36	**15.000**	45	36	..	30
13.756	48	17	19	39	**14.423**	45	24	30	39	**15.038**	60	19	20	42
13.765	39	17	27	45	**14.429**	55	18	17	36	**15.043**	48	27	33	39
13.776	45	21	27	42	**14.436**	48	19	24	42	**15.053**	39	19	33	45
13.788	42	36	39	33	**14.444**	39	36	..	27	**15.059**	48	17	24	45
13.804	48	17	22	45	**14.453**	51	19	21	39	**15.072**	45	19	21	33
13.816	42	19	30	48	**14.464**	45	20	27	42	**15.079**	60	21	19	36
13.823	55	21	19	36	**14.474**	55	19	24	48	**15.098**	55	17	21	45
13.841	60	17	20	51	**14.480**	48	17	20	39	**15.105**	48	22	27	39
13.846	48	24	27	39	**14.489**	51	22	30	48	**15.111**	51	30	24	27
13.853	48	21	20	33	**14.504**	39	22	27	33	**15.126**	45	21	36	51
13.866	45	21	33	51	**14.514**	55	20	19	36	**15.152**	45	33	30	27
13.878	51	21	24	42	**14.530**	51	27	30	39	**15.158**	48	19	27	45
13.884	42	22	24	33	**14.538**	42	20	27	39	**15.167**	42	36	39	30
13.889	45	27	30	36	**14.545**	48	36	..	33	**15.179**	51	24	30	42
13.897	42	17	27	48	**14.550**	55	27	30	42	**15.195**	39	22	36	42
13.904	39	17	20	33	**14.559**	36	17	33	48	**15.204**	42	17	24	39
13.909	51	30	27	33	**14.571**	51	21	27	45	**15.225**	55	17	24	51
13.919	60	21	19	39	**14.583**	42	36	30	24	**15.231**	36	20	33	39

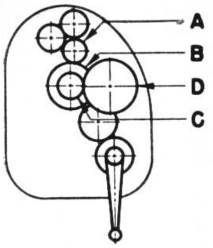


TABLE OF LEADS (15.241 to 17.550)

Lead of Spiral in Inches	A	B	C	D
15.241	45	17	19	33
15.256	51	18	21	39
15.273	42	33	36	30
15.278	55	24	24	36
15.294	42	21	39	51
15.300	51	20	27	45
15.306	45	21	30	42
15.311	48	19	20	33
15.321	39	20	33	42
15.338	51	19	24	42
15.354	48	18	19	33
15.385	45	39	36	27
15.395	39	19	36	48
15.400	42	20	33	45
15.407	39	27	48	45
15.429	36	21	27	30
15.439	55	19	24	45
15.441	42	17	30	48
15.455	51	36	..	33
15.469	45	20	33	48
15.476	45	27	39	42
15.502	36	19	27	33
15.513	55	20	22	39
15.529	36	17	33	45
15.547	48	19	24	39
15.556	42	36	..	27
15.571	45	17	30	51
15.577	45	20	27	39
15.587	55	19	21	39
15.600	39	20	36	45
15.612	51	21	27	42
15.620	42	22	27	33
15.625	45	36	30	24
15.632	33	19	27	30
15.642	45	22	39	51
15.658	51	19	21	36
15.670	55	27	30	39
15.686	48	18	30	51
15.692	51	20	24	39
15.714	48	24	33	42
15.724	33	39	..	21
15.734	45	22	30	39
15.741	51	27	30	36
15.750	42	24	27	30
15.762	55	17	19	39
15.772	39	17	33	48
15.789	30	42	..	19
15.817	55	17	22	45
15.824	48	21	27	39
15.833	51	17	19	36
15.865	45	24	33	39
15.873	55	21	20	33
15.882	27	42	..	17
15.889	39	30	33	27
15.909	42	33	30	24
15.918	39	21	36	42
15.928	48	17	22	39
15.938	51	20	30	48
15.955	39	22	27	30
15.966	60	17	19	42
15.983	51	27	33	39
16.000	48	36	..	30
16.032	36	19	33	39
16.042	42	36	33	24
16.049	51	22	27	39
16.071	45	24	36	42
16.082	55	19	20	36
16.105	51	19	27	45
16.117	55	21	24	39
16.127	55	18	19	36
16.134	48	21	36	51
16.150	51	20	19	30
16.162	48	33	30	27
16.176	55	17	24	48
16.190	51	21	30	45
16.200	36	20	27	30
16.211	42	19	33	45
16.239	60	18	19	39
16.250	39	36	..	24
16.257	48	17	19	33
16.283	55	19	27	48
16.290	36	17	30	39
16.296	48	27	33	36
16.313	51	18	19	33
16.327	48	21	30	42
16.333	42	18	21	30
16.346	51	24	30	39
16.364	36	39	..	22
16.370	39	27	51	45
16.387	45	21	39	51
16.397	45	19	27	39
16.404	51	19	22	36
16.410	48	27	36	39
16.421	39	19	36	45
16.450	60	21	19	33
16.471	42	17	30	45
16.484	45	21	30	39
16.500	33	36	..	20
16.508	48	27	39	42
16.518	51	19	24	39
16.529	60	22	20	33
16.544	45	17	30	48
16.558	51	22	30	42
16.579	42	19	36	48
16.593	42	27	48	45
16.609	48	17	30	51
16.615	48	20	27	39
16.623	48	21	24	33
16.639	36	17	33	42
16.667	45	36	..	27
16.684	48	22	39	51
16.696	51	24	33	42
16.705	42	22	21	24
16.714	39	20	36	42
16.725	39	19	22	27
16.736	45	22	27	33
16.762	48	21	33	45
16.776	51	19	30	48
16.783	48	22	30	39
16.794	39	19	27	33
16.800	42	20	36	45
16.806	55	30	33	36
16.813	51	21	27	39
16.824	39	17	33	45
16.837	45	21	33	42
16.845	45	22	42	51
16.852	42	36	39	27
16.859	51	22	24	33
16.875	45	24	27	30
16.886	55	19	21	36
16.904	42	19	39	51
16.917	45	19	30	42
16.923	55	20	24	39
16.947	55	17	22	42
16.970	42	33	36	27
16.985	42	17	33	48
17.000	51	36	..	30
17.017	45	17	27	42
17.028	55	19	30	51
17.045	45	33	30	24
17.053	36	19	27	30
17.063	42	20	39	48
17.075	55	17	19	36
17.081	51	19	21	33
17.094	60	27	30	39
17.105	39	19	30	36
17.112	48	17	20	33
17.128	45	17	33	51
17.143	36	39	..	21
17.172	51	33	30	27
17.182	42	22	27	30
17.195	60	17	19	39
17.206	39	17	36	48
17.225	36	19	30	33
17.236	55	27	33	39
17.255	55	17	24	45
17.273	51	17	19	33
17.308	45	24	36	39
17.316	60	21	20	33
17.326	36	17	27	33
17.333	48	36	39	30
17.347	51	21	30	42
17.355	42	33	30	22
17.368	33	39	..	19
17.376	48	17	24	39
17.386	51	24	27	33
17.411	45	24	39	42
17.421	55	17	21	39
17.439	42	17	36	51
17.455	48	33	36	30
17.471	33	17	27	30
17.479	48	21	39	51
17.490	48	19	27	39
17.500	42	39	..	24
17.531	51	20	33	48
17.540	39	27	51	42
17.550	39	20	27	30

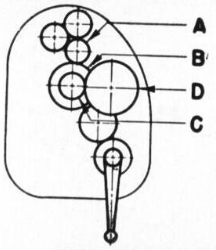


TABLE OF LEADS (17.582 to 20.588)

Lead of Spiral in Inches	A	B	C	D	Lead of Spiral in Inches	A	B	C	D	Lead of Spiral in Inches	A	B	C	D
17.582	48	21	30	39	**18.519**	60	27	30	36	**19.479**	51	24	33	36
17.593	60	18	19	36	**18.529**	42	17	36	48	**19.500**	39	36	. .	20
17.600	48	20	33	45	**18.545**	51	30	36	33	**19.522**	51	19	24	33
17.622	42	39	36	22	**18.571**	39	36	. .	21	**19.548**	48	17	27	39
17.630	42	27	51	45	**18.583**	51	19	27	39	**19.556**	48	30	33	27
17.647	30	39	. .	17	**18.595**	45	22	30	33	**19.592**	48	21	36	42
17.654	51	20	27	39	**18.609**	45	19	33	42	**19.608**	60	17	20	36
17.662	51	21	24	33	**18.627**	60	17	19	36	**19.615**	51	24	36	39
17.679	45	20	33	42	**18.660**	39	19	30	33	**19.636**	48	22	27	30
17.690	55	19	22	36	**18.673**	55	27	33	36	**19.643**	33	21	30	24
17.708	51	24	30	36	**18.685**	45	17	36	51	**19.664**	39	17	36	42
17.727	39	36	. .	22	**18.700**	51	20	33	45	**19.684**	51	19	33	45
17.763	45	19	36	48	**18.707**	55	21	30	42	**19.697**	45	33	39	27
17.778	48	33	. .	27	**18.731**	55	19	33	51	**19.732**	51	24	39	42
17.810	51	21	33	45	**18.750**	45	36	. .	24	**19.744**	42	18	33	39
17.824	55	18	21	36	**18.770**	39	17	27	33	**19.765**	42	17	36	45
17.832	51	22	30	39	**18.803**	55	18	24	39	**19.780**	45	21	36	39
17.843	42	18	39	51	**18.816**	39	19	33	36	**19.800**	36	30	33	20
17.851	48	22	27	33	**18.824**	48	18	36	51	**19.810**	48	21	39	45
17.857	60	24	30	42	**18.857**	48	20	33	42	**19.835**	48	22	30	33
17.875	39	30	33	24	**18.873**	55	17	21	36	**19.850**	48	19	33	42
17.898	45	22	42	48	**18.881**	45	22	36	39	**19.861**	39	27	33	24
17.919	36	17	33	39	**18.889**	51	33	. .	27	**19.870**	51	22	36	42
17.949	45	39	42	27	**18.900**	42	20	27	30	**19.895**	42	19	27	30
17.959	48	21	33	42	**18.909**	48	33	39	30	**19.910**	55	17	24	39
17.968	42	17	24	33	**18.947**	36	39	. .	19	**19.922**	45	24	51	48
17.981	51	24	33	39	**18.958**	42	36	39	24	**19.931**	48	17	36	51
18.000	36	39	. .	20	**18.967**	51	22	27	33	**20.000**	48	36	. .	24
18.006	55	24	33	42	**18.994**	45	22	39	42	**20.040**	45	19	33	39
18.025	39	17	33	42	**19.031**	55	17	30	51	**20.074**	42	17	39	48
18.030	51	18	21	33	**19.038**	45	20	33	39	**20.096**	42	19	30	33
18.045	48	19	30	42	**19.048**	55	21	24	33	**20.132**	51	19	36	48
18.056	45	36	39	27	**19.059**	36	17	27	30	**20.147**	55	21	30	39
18.086	42	19	27	33	**19.082**	51	21	33	42	**20.167**	55	20	22	30
18.092	55	19	30	48	**19.091**	42	36	. .	22	**20.192**	45	39	42	24
18.100	60	17	20	39	**19.097**	55	24	30	36	**20.202**	60	27	30	33
18.111	45	19	39	51	**19.118**	45	18	39	51	**20.211**	48	19	24	30
18.118	42	17	33	45	**19.125**	51	24	27	30	**20.222**	42	30	39	27
18.132	45	21	33	39	**19.139**	60	19	20	33	**20.238**	51	21	30	36
18.151	48	17	27	42	**19.145**	48	39	42	27	**20.250**	45	20	27	30
18.182	48	33	30	24	**19.158**	42	19	39	45	**20.260**	39	33	36	21
18.200	42	20	39	45	**19.173**	51	19	30	42	**20.301**	45	19	36	42
18.219	45	19	30	39	**19.192**	60	18	19	33	**20.321**	60	17	19	33
18.250	55	17	22	39	**19.206**	55	21	33	45	**20.342**	42	27	51	39
18.270	48	17	33	51	**19.231**	55	22	30	39	**20.362**	45	17	30	39
18.286	48	21	36	45	**19.243**	45	19	39	48	**20.370**	55	33	. .	27
18.308	42	30	51	39	**19.250**	42	30	33	24	**20.392**	48	18	39	51
18.326	45	17	27	39	**19.259**	48	36	39	27	**20.400**	51	20	24	30
18 333	55	33	. .	30	**19.286**	45	21	27	30	**20.408**	60	21	30	42
18.353	39	17	36	45	**19.298**	55	19	30	45	**20.433**	55	19	36	51
18.367	45	21	36	42	**19.319**	48	19	39	51	**20.455**	45	36	. .	22
18.373	48	19	24	33	**19.341**	48	21	33	39	**20.463**	51	36	39	27
18.384	42	33	39	27	**19.378**	45	19	27	33	**20.513**	45	27	48	39
18.409	45	22	27	30	**19.385**	42	20	36	39	**20.526**	39	36	. .	19
18.421	55	19	21	33	**19.394**	48	33	36	27	**20.535**	48	17	24	33
18.454	51	19	33	48	**19.412**	33	36	. .	17	**20.549**	51	21	33	39
18.462	48	24	36	39	**19.429**	51	21	36	45	**20.571**	48	21	27	30
18.474	39	19	27	30	**19.433**	48	19	30	39	**20.578**	55	21	33	42
18.487	55	17	24	42	**19.444**	45	36	42	27	**20.588**	55	17	21	33

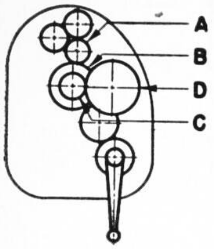


TABLE OF LEADS (20.606 to 24.740)

Lead of Spiral in Inches	A	B	C	D	Lead of Spiral in Inches	A	B	C	D	Lead of Spiral in Inches	A	B	C	D
20.606	51	33	36	27	**21.857**	51	21	27	30	**23.214**	45	36	39	21
20.625	45	30	33	24	**21.862**	45	19	36	39	**23.253**	48	17	42	51
20.635	39	21	30	27	**21.875**	45	36	42	24	**23.269**	55	20	33	39
20.648	51	19	30	39	**21.895**	48	19	39	45	**23.294**	36	17	33	30
20.670	48	19	27	33	**21.962**	51	19	27	33	**23.320**	48	19	36	39
20.682	42	33	39	24	**21.978**	60	21	30	39	**23.333**	42	36	..	18
20.706	48	17	33	45	**22.000**	48	30	33	24	**23.375**	51	30	33	24
20.719	51	20	39	48	**22.028**	45	39	42	22	**23.400**	39	30	36	20
20.741	48	36	42	27	**22.037**	42	27	51	36	**23.437**	45	24	30	24
20.769	45	20	36	39	**22.059**	45	17	30	36	**23.459**	48	19	39	42
20.778	51	30	33	27	**22.068**	39	36	55	27	**23.487**	51	19	42	48
20.798	45	17	33	42	**22.078**	51	21	30	33	**23.504**	55	18	30	39
20.805	48	19	42	51	**22.105**	42	36	..	19	**23.529**	55	17	24	33
20.816	51	21	36	42	**22.154**	48	20	36	39	**23.538**	51	20	36	39
20.826	42	33	36	22	**22.185**	48	17	33	42	**23.579**	48	19	42	45
20.833	45	27	30	24	**22.222**	48	36	45	27	**23.611**	51	27	30	24
20.842	36	30	33	19	**22.235**	42	17	27	30	**23.636**	48	33	39	24
20.856	39	17	30	33	**22.243**	55	17	33	48	**23.684**	45	33	..	19
20.864	51	22	27	30	**22.262**	51	21	33	36	**23.725**	55	17	22	30
20.905	42	17	33	39	**22.286**	39	30	36	21	**23.765**	42	27	55	36
20.934	55	17	33	51	**22.313**	51	20	42	48	**23.800**	51	20	42	45
20.952	48	21	33	36	**22.323**	51	33	39	27	**23.810**	45	21	30	27
20.979	60	22	30	39	**22.344**	39	24	33	24	**23.824**	45	17	27	30
21.000	42	39	..	20	**22.368**	51	19	30	36	**23.833**	39	27	33	20
21.010	48	33	39	27	**22.392**	39	33	36	19	**23.864**	45	33	42	24
21.029	39	17	33	36	**22.400**	48	20	42	45	**23.891**	48	17	33	39
21.053	55	19	24	33	**22.418**	51	21	36	39	**23.947**	42	19	39	36
21.074	51	22	30	33	**22.449**	55	21	36	42	**23.974**	51	18	33	39
21.099	48	21	36	39	**22.460**	42	17	30	33	**24.000**	48	33	..	20
21.154	55	20	30	39	**22.500**	45	36	..	20	**24.040**	51	33	42	27
21.176	36	39	..	17	**22.551**	51	21	39	42	**24.063**	42	24	33	24
21.212	45	33	42	27	**22.564**	48	18	33	39	**24.074**	55	27	39	33
21.228	55	19	22	30	**22.579**	39	30	33	19	**24.115**	42	33	36	19
21.250	51	33	..	24	**22.588**	48	17	36	45	**24.123**	55	19	30	36
21.273	39	30	36	22	**22.626**	42	27	48	33	**24.158**	51	19	27	30
21.316	45	19	27	30	**22.667**	51	30	36	27	**24.176**	55	21	36	39
21.333	48	30	36	27	**22.689**	45	17	36	42	**24.202**	48	17	36	42
21.377	48	19	33	39	**22.698**	39	27	33	21	**24.231**	45	20	42	39
21.389	42	27	33	24	**22.713**	51	19	33	39	**24.242**	48	33	45	27
21.399	51	22	36	39	**22.727**	45	27	30	22	**24.265**	55	17	36	48
21.412	42	17	39	45	**22.737**	48	19	27	30	**24.286**	51	33	..	21
21.429	45	36	..	21	**22.744**	55	19	33	42	**24.292**	60	19	30	39
21.450	39	30	33	20	**22.750**	42	30	39	24	**24.316**	42	30	33	19
21.474	51	19	36	45	**22.768**	51	21	45	48	**24.375**	45	30	39	24
21.507	45	17	39	48	**22.805**	42	17	36	39	**24.402**	51	19	30	33
21.526	51	22	39	42	**22.837**	55	17	36	51	**24.434**	45	17	36	39
21.538	48	24	42	39	**22.857**	48	33	..	21	**24.444**	55	30	36	27
21.577	51	20	33	39	**22.885**	51	24	42	39	**24.471**	48	17	39	45
21.592	48	17	39	51	**22.909**	42	30	36	22	**24.494**	55	19	33	39
21.607	55	20	33	42	**22.917**	55	30	..	24	**24.519**	45	24	51	39
21.636	51	33	42	30	**22.941**	39	36	..	17	**24.545**	45	30	36	22
21.654	48	19	36	42	**22.967**	48	19	30	33	**24.561**	42	19	30	27
21.667	39	36	..	18	**23.008**	51	19	36	42	**24.580**	45	17	39	42
21.711	55	19	36	48	**23.021**	51	24	39	36	**24.605**	51	19	33	36
21.719	48	17	30	39	**23.077**	48	24	45	39	**24.615**	48	21	42	39
21.795	51	18	30	39	**23.100**	42	30	33	20	**24.632**	39	30	36	19
21.809	51	19	39	48	**23.111**	48	30	39	27	**24.706**	42	36	..	17
21.818	48	33	..	22	**23.158**	55	19	24	30	**24.727**	48	22	51	45
21.825	55	21	30	36	**23.182**	51	33	..	22	**24.740**	55	17	39	51

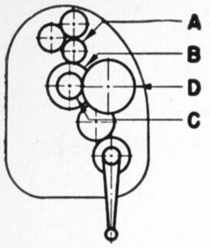


TABLE OF LEADS (24.750 to 30.390)

Lead of Spiral in Inches	A	B	C	D	Lead of Spiral in Inches	A	B	C	D	Lead of Spiral in Inches	A	B	C	D
24.750	45	30	33	20	**26.353**	48	17	42	45	**28.373**	55	21	39	36
24.762	39	27	36	21	**26.374**	48	21	45	39	**28.421**	45	30	36	19
24.777	51	19	36	39	**26.400**	48	30	33	20	**28.437**	42	24	39	24
24.793	60	22	30	33	**26.442**	45	24	55	39	**28.507**	45	17	42	39
24.826	55	24	39	36	**26.471**	45	36	..	17	**28.519**	55	27	42	30
24.887	55	17	30	39	**26.494**	51	33	36	21	**28.547**	55	17	45	51
24.914	48	17	45	51	**26.526**	42	30	36	19	**28.571**	48	21	30	24
24.925	51	19	39	42	**26.535**	55	19	33	36	**28.636**	45	30	42	22
24.935	48	33	36	21	**26.591**	45	30	39	22	**28.676**	45	36	39	17
24.965	51	22	42	39	**26.644**	55	17	42	51	**28.701**	51	33	39	21
25.000	51	17	30	36	**26.667**	48	36	..	18	**28.718**	48	18	42	39
25.027	39	33	36	17	**26.714**	51	30	33	21	**28.737**	42	30	39	19
25.053	51	19	42	45	**26.748**	51	22	45	39	**28.759**	51	19	45	42
25.088	39	27	33	19	**26.765**	42	36	39	17	**28.810**	55	30	33	21
25.114	51	33	39	24	**26.786**	45	21	30	24	**28.875**	42	24	33	20
25.143	48	30	33	21	**26.812**	39	24	33	20	**28.889**	48	27	39	24
25.175	48	22	45	39	**26.842**	51	33	..	19	**28.907**	51	19	42	39
25.200	42	30	36	20	**26.880**	55	19	39	42	**28.947**	45	27	33	19
25.210	60	17	30	42	**26.952**	42	33	36	17	**28.977**	51	24	45	33
25.235	39	17	33	30	**26.984**	51	21	30	27	**29.079**	51	19	39	36
25.263	48	33	..	19	**27.000**	45	30	36	20	**29.091**	48	33	42	21
25.278	42	27	39	24	**27.018**	42	27	33	19	**29.101**	55	21	30	27
25.289	51	33	36	22	**27.045**	51	33	42	24	**29.118**	45	17	33	30
25.325	45	33	39	21	**27.068**	48	19	45	42	**29.143**	51	30	36	21
25.385	60	20	33	39	**27.083**	55	24	39	33	**29.167**	45	27	42	24
25.397	48	21	30	27	**27.149**	60	17	30	39	**29.198**	42	33	39	17
25.412	48	17	27	30	**27.176**	42	17	33	30	**29.221**	45	21	30	22
25.420	55	17	33	42	**27.206**	48	19	42	39	**29.250**	45	30	39	20
25.455	48	33	42	24	**27.273**	48	33	45	24	**29.282**	51	33	36	19
25.463	55	27	30	24	**27.300**	42	30	39	20	**29.333**	48	27	33	20
25.490	39	17	30	27	**27.368**	39	27	36	19	**29.412**	60	17	30	36
25.500	51	33	..	20	**27.397**	51	33	39	22	**29.423**	51	20	45	39
25.536	39	24	33	21	**27.429**	48	30	36	21	**29.474**	42	27	36	19
25.568	45	24	30	22	**27.462**	51	20	42	39	**29.504**	51	22	42	33
25.641	60	18	30	39	**27.500**	55	33	..	20	**29.526**	51	30	33	19
25.658	45	36	39	19	**27.529**	39	30	36	17	**29.545**	45	27	39	22
25.668	48	17	30	33	**27.560**	48	33	36	19	**29.605**	45	19	30	24
25.714	45	30	36	21	**27.576**	42	27	39	22	**29.630**	48	18	30	27
25.758	51	27	30	22	**27.632**	45	19	42	36	**29.657**	55	17	33	36
25.785	48	33	39	22	**27.692**	48	20	45	39	**29.683**	51	27	33	21
25.837	45	33	36	19	**27.731**	55	17	36	42	**29.714**	48	30	39	21
25.846	48	20	42	39	**27.755**	51	21	48	42	**29.750**	51	30	42	24
25.855	55	18	33	39	**27.769**	48	33	42	22	**29.774**	36	21	33	19
25.882	55	17	36	45	**27.789**	48	30	33	19	**29 792**	55	30	39	24
25.905	51	21	48	45	**27.818**	51	30	36	22	**29.825**	51	19	30	27
25.926	42	18	30	27	**27.857**	45	30	39	21	**29.864**	55	17	36	39
25.972	51	27	33	24	**27.937**	48	27	33	21	**29.890**	51	21	48	39
26.000	48	30	39	24	**27.990**	45	33	39	19	**30.000**	55	30	36	22
26.020	51	21	45	42	**28.009**	55	27	33	24	**30.042**	55	17	39	42
26.033	45	33	42	22	**28.022**	51	21	45	39	**30.136**	51	30	39	22
26.053	45	30	33	19	**28.039**	55	17	39	45	**30 144**	45	33	42	19
26.063	48	17	36	39	**28.050**	51	30	33	20	**30.196**	42	17	33	27
26.124	42	33	39	19	**28.070**	48	19	30	27	**30.222**	51	30	48	27
26.154	51	21	42	39	**28.125**	45	24	36	24	**30.252**	48	17	45	42
26.182	48	30	36	22	**28.224**	39	24	33	19	**30.303**	60	22	30	27
26.218	48	17	39	42	**28.235**	48	36	..	17	**30.316**	48	30	36	19
26.250	45	30	42	24	**28.283**	60	27	42	33	**30.333**	42	27	39	20
26.287	55	17	39	48	**28.309**	55	17	42	48	**30.357**	51	21	30	24
26.310	51	21	39	36	**28.333**	51	27	33	22	**30.390**	39	22	36	21

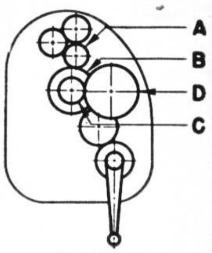


TABLE OF LEADS (30.407 to 37.227)

Lead of Spiral in Inches	A	B	C	D	Lead of Spiral in Inches	A	B	C	D	Lead of Spiral in Inches	A	B	C	D
30.407	48	17	42	39	**32.566**	45	24	33	19	**34.895**	51	30	39	19
30.450	55	17	48	51	**32.579**	48	17	45	39	**34.921**	55	27	36	21
30.476	48	27	36	21	**32.692**	51	18	45	39	**35.000**	48	24	42	24
30.513	51	18	42	39	**32.727**	51	33	36	17	**35.049**	55	17	39	36
30.545	48	30	42	22	**32.738**	55	21	30	24	**35.065**	45	22	36	21
30.556	55	24	36	27	**32.807**	51	27	33	19	**35.079**	51	27	39	21
30.588	39	17	36	27	**32.842**	48	30	39	19	**35.088**	60	19	30	27
30.600	51	30	36	20	**32.906**	55	18	42	39	**35.188**	39	21	36	19
30.643	39	20	33	21	**32.941**	42	27	36	17	**35.256**	55	18	45	39
30.677	51	19	48	42	**33.000**	48	24	33	20	**35.294**	45	27	36	17
30.694	51	27	39	24	**33.016**	48	27	39	21	**35.325**	51	21	48	33
30.769	48	18	45	39	**33.036**	51	19	48	39	**35.357**	45	21	33	20
30.789	45	30	39	19	**33.056**	51	27	42	24	**35.368**	48	30	42	19
30.802	48	33	36	17	**33.088**	45	17	30	24	**35.380**	55	27	33	19
30.882	45	36	42	17	**33.117**	51	21	30	22	**35.417**	51	27	45	24
30.909	51	27	36	22	**33.158**	45	30	42	19	**35.455**	42	22	39	21
30.937	45	24	33	20	**33.239**	45	24	39	22	**35.526**	45	24	36	19
30.952	45	27	39	21	**33.277**	36	17	33	21	**35.556**	48	27	42	21
30.972	51	19	45	39	**33.333**	55	27	36	22	**35.588**	55	17	33	30
31.023	42	24	39	22	**33.369**	48	33	39	17	**35.648**	55	27	42	24
31.059	48	17	33	30	**33.393**	51	24	33	21	**35.686**	42	27	39	17
31.111	48	27	42	24	**33.429**	39	21	36	20	**35.700**	51	30	42	20
31.167	51	27	33	20	**33.485**	51	27	39	22	**35.714**	60	21	30	24
31.200	48	30	39	20	**33.553**	51	19	30	24	**35.750**	55	20	39	30
31.250	60	24	30	24	**33.589**	39	22	36	19	**35.795**	45	24	42	22
31.283	45	33	39	17	**33.611**	55	27	33	20	**35.921**	42	24	39	19
31.316	51	19	42	36	**33.684**	48	27	36	19	**35.936**	48	17	42	33
31.360	55	19	39	36	**33.704**	42	27	39	18	**35.948**	55	17	30	27
31 385	51	20	48	39	**33.719**	51	22	48	33	**35.962**	51	20	55	39
31.429	55	30	36	21	**33.750**	45	24	36	20	**36.000**	51	30	36	17
31.481	51	18	30	27	**33.772**	55	19	42	36	**36.012**	55	24	33	21
31.500	45	30	42	20	**33.846**	48	20	55	39	**36.050**	39	17	33	21
31.515	48	27	39	22	**33.868**	39	19	33	20	**36.061**	51	27	42	22
31.544	39	17	33	24	**33.882**	48	30	36	17	**36.096**	45	17	30	22
31.571	51	30	39	21	**33.939**	48	27	42	22	**36.111**	55	27	39	22
31.612	51	22	45	33	**33.951**	55	18	30	27	**36.172**	42	22	36	19
31.722	51	33	39	19	**33.971**	42	17	33	24	**36.184**	55	19	45	36
31.746	60	21	30	27	**34.000**	51	30	48	24	**36.364**	48	27	45	22
31.765	45	30	36	17	**34.048**	55	30	39	21	**36.397**	45	17	33	24
31.818	45	27	42	22	**34.091**	55	22	45	33	**36.429**	51	30	45	21
31.842	55	30	33	19	**34.125**	42	24	39	20	**36.474**	42	19	33	20
31.875	51	30	45	24	**34.163**	51	19	42	33	**36.491**	48	27	39	19
31.909	39	22	36	20	**34.211**	45	27	39	19	**36.562**	45	24	39	20
31.930	42	27	39	19	**34.249**	51	21	55	39	**36.603**	51	19	45	33
32.000	48	21	42	30	**34.286**	48	24	36	21	**36.667**	55	27	36	20
32.011	55	27	33	21	**34.375**	55	30	45	24	**36.706**	48	30	39	17
32.083	42	18	33	24	**34.412**	45	30	39	17	**36.818**	45	22	36	20
32.118	42	30	39	17	**34 450**	48	19	30	22	**36.842**	55	19	42	33
32.143	45	24	36	21	**34 510**	48	17	33	27	**36.908**	51	24	33	19
32.164	55	19	30	27	**34 531**	51	24	39	24	**36.923**	51	17	48	39
32.211	51	30	36	19	**34 615**	51	17	45	39	**36.947**	39	20	36	19
32.231	60	22	39	33	**34.630**	51	18	33	27	**36.975**	55	17	48	42
32.256	39	19	33	21	**34 667**	48	27	39	20	**37.037**	60	18	30	27
32.297	45	19	30	22	**34.711**	60	22	42	33	**37.059**	45	30	42	17
32.308	51	17	42	39	**34 737**	48	19	33	24	**37.091**	51	22	48	30
32.353	45	17	33	27	**34.773**	51	30	45	22	**37.143**	48	24	39	21
32.381	51	27	36	21	**34.821**	45	24	39	21	**37.187**	51	24	42	24
32.455	51	30	42	22	**34.842**	55	17	42	39	**37.218**	45	21	33	19
32.500	48	24	39	24	**34 872**	51	18	48	39	**37.227**	42	22	39	20

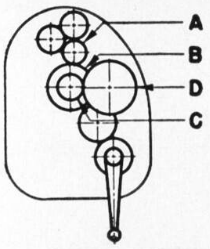


TABLE OF LEADS (37.240 to 46.324)

Lead of Spiral in Inches	A	B	C	D	Lead of Spiral in Inches	A	B	C	D	Lead of Spiral in Inches	A	B	C	D
37.240	55	24	39	24	**40.000**	51	27	36	17	**43.105**	42	20	39	19
37.321	60	19	39	33	**40.071**	51	21	33	20	**43.137**	55	27	36	17
37.346	55	18	33	27	**40.104**	55	24	42	24	**43.175**	51	27	48	21
37.403	48	22	36	21	**40.147**	42	24	39	17	**43.214**	55	21	33	20
37.500	55	24	36	22	**40.191**	60	19	42	33	**43.308**	48	21	36	19
37.540	39	17	36	22	**40.263**	51	24	36	19	**43.333**	51	27	39	17
37.579	51	30	42	19	**40.428**	42	22	36	17	**43.421**	55	19	36	24
37.632	55	19	39	30	**40.441**	55	17	45	36	**43.466**	51	24	45	22
37.647	48	27	36	17	**40.476**	51	27	45	21	**43.618**	51	24	39	19
37.670	51	24	39	22	**40.519**	48	22	39	21	**43.636**	48	22	42	21
37.714	48	21	33	20	**40.568**	51	24	42	22	**43.651**	55	21	45	27
37.745	55	17	42	36	**40.602**	45	21	36	19	**43.676**	45	17	33	20
37.778	51	27	48	24	**40.625**	60	24	39	24	**43.714**	51	21	36	20
37.812	55	24	33	20	**40.741**	55	27	42	21	**43.750**	60	24	42	24
37.831	55	27	39	21	**40.765**	42	17	33	20	**43.797**	42	22	39	17
37.853	39	17	33	20	**40.784**	48	27	39	17	**43.923**	51	22	36	19
37.895	48	30	45	19	**40.800**	51	20	48	30	**43.985**	45	21	39	19
37.917	42	24	39	18	**40.909**	60	20	30	22	**44.000**	48	18	33	20
37.987	45	22	39	21	**40.926**	51	27	39	18	**44.074**	51	27	42	18
38.182	48	24	42	22	**41.053**	48	24	39	19	**44.118**	60	17	30	24
38.194	55	27	45	24	**41.143**	48	21	36	20	**44.136**	55	18	39	27
38.235	45	27	39	17	**41.176**	45	27	42	17	**44.211**	48	24	42	19
38.250	51	24	36	20	**41.212**	51	27	48	22	**44.289**	51	20	33	19
38.487	45	24	39	19	**41.250**	55	24	36	20	**44.318**	60	24	39	22
38.500	55	20	42	30	**41.270**	60	21	39	27	**44.370**	48	17	33	21
38.519	48	27	39	18	**41.294**	39	17	36	20	**44.444**	48	27	45	18
38.571	45	21	36	20	**41.340**	48	22	36	19	**44.471**	42	20	36	17
38.596	55	27	36	19	**41.364**	42	22	39	18	**44.485**	55	17	33	24
38.636	51	27	45	22	**41.437**	51	24	39	20	**44.524**	51	18	33	21
38.756	45	22	36	19	**41.481**	48	27	42	18	**44.571**	48	21	39	20
38.772	51	27	39	19	**41.597**	45	17	33	21	**44.625**	51	24	42	20
38.824	48	17	33	24	**41.667**	55	27	45	22	**44.687**	55	24	39	20
38.857	51	30	48	21	**41.684**	48	19	33	20	**44.737**	51	27	45	19
38.889	60	24	42	27	**41.711**	60	17	39	33	**44.785**	48	22	39	19
38.958	51	18	33	24	**41.727**	51	22	36	20	**44.920**	60	17	42	33
39.000	51	30	39	17	**41.754**	51	27	42	19	**45.000**	55	22	36	20
39.043	51	19	48	33	**41.786**	45	21	39	20	**45.029**	55	19	42	27
39.079	45	20	33	19	**41.813**	55	27	39	19	**45.205**	51	22	39	20
39.187	42	22	39	19	**41.905**	48	18	33	21	**45.215**	45	22	42	19
39.216	60	17	30	27	**41.986**	45	22	39	19	**45.294**	55	17	42	30
39.273	48	22	36	20	**42.000**	48	24	42	20	**45.333**	51	27	48	20
39.286	55	22	33	21	**42.014**	55	18	33	24	**45.378**	45	21	36	17
39.298	48	27	42	19	**42.059**	55	17	39	30	**45.455**	60	22	45	27
39.328	39	17	36	21	**42.105**	48	27	45	19	**45.474**	48	20	36	19
39.375	45	24	42	20	**42.180**	51	21	33	19	**45.489**	55	21	33	19
39.394	60	22	39	27	**42.308**	55	17	51	39	**45.500**	42	20	39	18
39.464	51	24	39	21	**42.353**	48	30	45	17	**45.536**	51	24	45	21
39.474	55	19	45	33	**42.424**	60	22	42	27	**45.614**	60	19	39	27
39.529	48	30	42	17	**42.500**	51	27	45	20	**45.714**	48	21	36	18
39.542	55	17	33	27	**42.545**	48	22	39	20	**45.818**	48	22	42	20
39.667	51	27	42	20	**42.560**	55	24	39	21	**45.833**	55	24	48	24
39.699	48	21	33	19	**42.632**	45	20	36	19	**45.882**	48	24	39	17
39.722	55	27	39	20	**42.778**	55	27	42	20	**45.975**	45	17	33	19
39.740	51	22	36	21	**42.910**	42	17	33	19	**46.015**	51	21	36	19
39.789	42	20	36	19	**42.947**	51	19	48	30	**46.042**	51	24	39	18
39.803	55	24	33	19	**42.969**	55	24	45	24	**46.184**	45	20	39	19
39.819	55	17	48	39	**43.015**	45	24	39	17	**46.203**	48	22	36	17
39.845	39	17	33	19	**43.052**	51	22	39	21	**46.316**	48	18	33	19
39.886	45	22	39	20	**43.062**	60	19	30	22	**46.324**	45	24	42	17

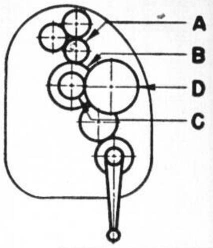


TABLE OF LEADS (46.364 to 60.662)

Lead of Spiral in Inches	A	B	C	D
46.364	51	24	48	22
46.429	60	24	39	21
46.561	55	21	48	27
46.588	48	17	33	20
46.667	51	27	42	17
46.732	55	27	39	17
46.753	48	21	45	22
46.811	42	17	36	19
46.875	60	24	45	24
46.925	45	22	39	17
46.974	51	24	42	19
47.039	55	24	39	19
47.059	48	27	45	17
47.143	55	21	36	20
47.222	51	27	45	18
47.273	48	22	39	18
47.357	51	21	39	20
47.531	55	18	42	27
47.584	51	22	39	19
47.619	60	21	45	27
47.647	45	20	36	17
47.719	51	27	48	19
47.763	55	20	33	19
47.812	51	24	45	20
47.895	42	19	39	18
48.000	48	21	42	20
48.016	55	18	33	21
48.125	55	24	42	20
48.148	60	18	39	27
48.176	42	20	39	17
48.230	48	22	42	19
48.246	55	19	45	27
48.316	51	20	36	19
48.403	48	21	36	17
48.485	60	22	48	27
48.529	55	24	36	17
48.571	51	24	48	21
48.698	55	24	51	24
48.750	55	22	39	20
48.889	55	20	48	27
49.040	48	17	33	19
49.091	51	22	36	17
49.107	55	24	45	21
49.123	60	19	42	27
49.160	45	21	39	17
49.211	55	19	51	30
49.263	48	20	39	19
49.412	60	17	42	30
49.471	55	21	51	27
49.500	51	17	33	20
49.524	48	21	39	18
49.583	51	24	42	18
49.624	55	21	36	19
49.653	55	24	39	18
49.675	51	22	45	21
49.737	45	20	42	19
49.850	51	21	39	19
50.000	55	24	48	22
50.053	48	22	39	17
50.155	45	19	36	17
50.227	51	22	39	18
50.329	51	24	45	19
50.370	51	27	48	18
50.417	55	18	33	20
50.526	48	21	42	19
50.649	60	22	39	21
50.712	42	19	39	17
50.794	60	21	48	27
50.824	48	20	36	17
50.840	55	17	33	21
50.909	48	22	42	18
50.926	55	18	45	27
50.980	60	17	39	27
51.000	51	24	48	20
51.071	55	21	39	20
51.136	60	22	45	24
51.244	51	19	42	22
51.316	55	22	39	19
51.429	48	21	45	20
51.462	55	19	48	27
51.562	55	24	45	20
51.618	45	20	39	17
51.675	48	22	45	19
51.852	60	18	42	27
51.944	55	20	51	27
52.000	48	20	39	18
52.105	55	20	36	19
52.159	51	22	45	20
52.342	51	20	39	19
52.381	55	24	48	21
52.437	48	21	39	17
52.500	55	22	42	20
52.574	55	24	39	17
52.632	60	19	45	27
52.941	48	24	45	17
52.987	51	22	48	21
53.053	48	20	42	19
53.070	55	18	33	19
53.125	55	24	51	22
53.182	60	22	39	20
53.333	51	27	48	17
53.382	55	17	33	20
53.472	55	24	42	18
53.498	48	19	36	17
53.529	42	18	39	17
53.571	55	22	45	21
53.684	51	24	48	19
53.759	55	21	39	19
53.904	48	22	42	17
53.922	55	17	45	27
54.000	51	20	36	17
54.091	51	22	42	18
54.135	48	21	45	19
54.167	55	22	39	18
54.276	55	19	45	24
54.321	55	18	48	27
54.334	45	19	39	17
54.545	60	22	48	24
54.643	51	21	45	20
54.678	55	19	51	27
54.737	48	19	39	18
54.902	60	17	42	27
55.000	55	24	48	20
55.059	48	20	39	17
55.250	51	20	39	18
55.263	55	22	42	19
55.462	55	21	36	17
55.556	60	18	45	27
55.588	45	20	42	17
55.636	51	22	48	20
55.655	55	24	51	21
55.714	60	21	39	20
55.981	60	22	39	19
56.000	48	20	42	18
56.140	60	19	48	27
56.192	55	17	33	19
56.250	55	22	45	20
56.368	51	20	42	19
56.447	55	20	39	19
56.471	48	21	42	17
56.618	55	24	42	17
56.667	51	24	48	18
56.746	55	21	39	18
56.842	51	19	36	17
57.143	55	22	48	21
57.273	60	22	42	20
57.292	55	24	45	18
57.353	55	22	39	17
57.519	51	21	45	19
57.716	55	18	51	27
57.754	48	22	45	17
57.895	55	24	48	19
57.957	48	19	39	17
58.158	51	19	39	18
58.235	55	20	36	17
58.286	51	21	48	20
58.333	55	22	42	18
58.437	55	24	51	20
58.500	51	20	39	17
58.514	45	19	42	17
58.565	51	22	48	19
58.647	60	21	39	19
58.824	60	17	45	27
58.929	55	21	45	20
58.947	48	19	42	18
59.091	60	22	39	18
59.211	55	22	45	19
59.259	60	18	48	27
59.294	48	20	42	17
59.500	51	20	42	18
59.583	55	20	39	18
60.000	60	21	42	20
60.084	55	21	39	17
60.287	60	19	42	22
60.395	51	20	45	19
60.504	48	21	45	17
60.662	55	17	45	24

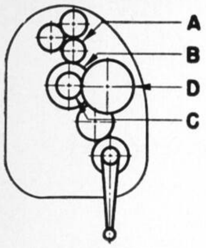


TABLE OF LEADS (60.714 to 107.843)

Lead of Spiral in Inches	A	B	C	D
60.714	55	22	51	21
60.789	55	20	42	19
61.111	55	21	42	18
61.176	48	18	39	17
61.300	55	19	36	17
61.364	51	22	45	17
61.513	55	19	51	24
61.579	60	20	39	19
61.765	55	22	42	17
61.818	51	22	48	18
61.905	60	21	39	18
62.030	55	21	45	19
62.338	60	21	48	22
62.415	48	19	42	17
62.500	55	22	45	18
62.567	60	22	39	17
62.632	51	19	42	18
62.719	55	19	39	18
62.745	60	17	48	27
62.857	55	21	48	20
62.963	60	18	51	27
63.000	51	20	42	17
63.088	55	20	39	17
63.158	55	22	48	19
63.529	48	20	45	17
63.636	60	18	42	22
63.750	55	22	51	20
64.167	55	18	42	20
64.286	60	21	45	20
64.421	51	20	48	19
64.593	60	19	45	22
64.706	55	21	42	17
64.762	51	21	48	18
64.931	55	18	51	24
65.000	60	20	39	18
65.132	55	20	45	19
65.455	60	20	48	22
65.476	55	21	45	18
65.546	60	21	39	17
65.882	48	18	42	17
66.165	55	21	48	19
66.234	60	21	51	22
66.316	60	20	42	19
66.409	55	19	39	17
66.667	60	21	42	18
66.786	55	21	51	20
66.873	48	19	45	17
67.105	55	22	51	19
67.380	60	17	42	22
67.500	51	20	45	17
67.554	55	19	42	18
67.669	60	19	45	21
67.941	55	20	42	17
68.000	51	20	48	18
68.182	60	18	45	22
68.421	60	19	39	18
68.571	60	20	48	21
68.750	55	20	45	18
68.824	60	20	39	17
68.900	60	19	48	22
69.328	55	21	45	17
69.474	55	20	48	19
69.545	60	20	51	22
69.841	55	21	48	18
70.000	60	20	42	18
70.098	55	18	39	17
70.301	55	21	51	19
70.588	55	22	48	17
70.833	55	22	51	18
71.053	60	19	45	20
71.429	60	18	45	21
71.517	55	19	42	17
71.579	51	19	48	18
72.000	51	20	48	17
72.180	60	19	48	21
72.368	55	19	45	18
72.446	60	19	39	17
72.727	60	18	48	22
72.794	55	20	45	17
72.857	60	20	51	21
73.206	60	19	51	22
73.333	55	20	48	18
73.684	60	19	42	18
73.816	55	20	51	19
73.950	55	21	48	17
74.118	60	20	42	17
74.206	55	21	51	18
75.000	55	22	51	17
75.490	55	18	42	17
75.630	60	17	45	21
75.789	51	19	48	17
76.190	60	18	48	21
76.471	60	18	39	17
76.625	55	19	45	17
76.692	60	19	51	21
77.005	60	17	48	22
77.193	55	19	48	18
77.273	60	18	51	22
77.647	55	20	48	17
77.917	55	20	51	18
78.019	60	19	42	17
78.571	55	21	51	17
78.947	60	18	45	19
79.412	60	17	45	20
80.000	51	18	48	17
80.526	60	19	51	20
80.672	60	17	48	21
80.882	55	18	45	17
80.952	60	18	51	21
81.734	55	19	48	17
81.818	60	17	51	22
82.018	55	19	51	18
82.353	60	18	42	17
82.500	55	20	51	17
82.707	60	19	55	21
83.333	60	18	55	22
83.591	60	19	45	17
84.211	60	18	48	19
84.706	60	17	48	20
85.000	60	18	51	20
85.714	60	17	51	21
86.275	55	18	48	17
86.842	55	19	51	17
87.302	60	18	55	21
88.235	60	18	45	17
89.164	60	17	48	19
89.474	60	18	51	19
90.000	60	17	51	20
91.667	60	18	55	20
92.437	60	17	55	21
94.118	60	18	48	17
94.737	60	17	51	19
96.491	60	18	55	19
97.059	60	17	55	20
100.000	60	17	51	18
102.167	60	17	55	19
107.843	60	17	55	18

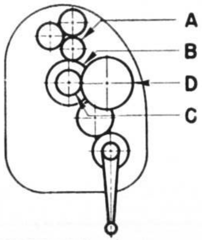


TABLE OF CHANGE GEARS, APPROXIMATE ANGLES AND ENGLISH LEADS FOR CUTTING SPIRALS

Lead of Spiral Inches	A	B	C	D	DIAMETER OF WORK																							
	Driven	Driver	Driven	Driver	⅛ In.	¼ In.	⅜ In.	½ In.	⅝ In.	¾ In.	⅞ In.	1 In.	1¼ In.	1½ In.	1¾ In.	2 In.	2¼ In.	2½ In.	2¾ In.	3 In.	3¼ In.	3½ In.	3¾ In.	4 In.	4½ In.	5 In.	5½ In.	6 In.
2.50	27	45	20	48	8¾	17	25	32	38	43¼																		
2.78	20	45	30	48	8	15½	23	29½	35¼	40½	44¾																	
2.92	21	45	30	48	7½	15	21¾	28¼	34	39	43¼																	
3.24	27	33	19	48	6¾	13¼	19¾	25¾	31¼	36	40½	44¼																
3.70	27	33	19	42	6	11¾	17½	23	28	32½	36½	40½																
3.89	30	36	21	45	5½	11¼	16¾	22	26¾	31¼	35¼	39																
4.17	39	33	18	51	5¼	10½	15¾	20½	25¼	29½	33½	37	43¼															
4.46	39	36	21	51	4¾	9¾	14¾	19¼	23¾	27¾	31½	35	41½															
4.86	42	36	20	48	4½	9	13½	17¾	22	25¾	29½	33	39	44¼														
5.33	33	27	17	39	4	8¼	12¼	16½	20¼	23¾	27¼	30½	36½	44¼														
5.44	33	39	27	42	4	8	12	16	20	23½	26¾	30	36	41														
6.12	27	21	20	42	3½	7¼	11	14½	17¾	21	24¼	27	33	37¾	42													
6.22	33	24	19	42	3½	7	10¾	14¼	17½	20¾	23¾	26¾	32½	37¼	41½													
6.48	42	27	20	48	3¼	6¾	10¼	13½	16¾	20	23	25¾	31½	36¼	40¼	44¼												
6.67	30	36	.....	45	3¼	6½	10	13¼	16½	19½	22½	25¼	30¾	35¼	39½	43½												
7.29	45	27	21	48	3	6¼	9¼	12¼	15	18	20½	23½	28½	33	37	41	44¼											
7.41	51	30	17	39	3	6	9	12	14¾	17¾	20¼	22¾	28¼	32½	36½	40¼	43¾											
7.62	45	22	19	51	2¾	5¾	8¾	11½	14½	17¼	19¾	22¼	27½	32	36	39½	43											
8.33	30	39	.....	36	2½	5¼	8	10½	13¼	15¾	18¼	20½	25½	29½	33½	37	40½	43½										
8.95	48	33	24	39	2½	5	7½	10	12½	14¾	17	19¼	24	28	31¾	35¼	38½	41¼	44									
9.33	42	30	24	36	2¼	4¾	7¼	9½	11¾	14	16¼	18½	23	27	30½	34	37½	40¼	43									
9.52	33	24	27	39	2¼	4½	7	9¼	11½	13¾	16	18¼	22½	26½	30	33½	36½	39½	42¼	45								
10.29	39	20	19	36	2	4¼	6½	8¾	10¾	12¾	15	17¼	21	24¾	28¼	31½	34½	37½	40	42½	45							
10.37	42	27	24	36	2	4¼	6½	8½	10½	12¾	14¾	17	20¾	24½	28	31¼	34¼	37¼	39¾	42¼	44¾							
10.50	21	45	.....	20	2	4¼	6¼	8½	10½	12½	14½	16¾	20½	24¼	27¾	31	34	36¾	39½	42	44¼							
10.67	55	27	22	42	2	4	6¼	8¼	10¼	12¼	14¼	16½	20¼	24	27¼	30½	33½	36½	39	41½	43¾							
10.94	48	27	24	39	2	4	6	8¼	10¼	12	14	16¼	20	23½	26¾	30	33	35¾	38¼	40¾	43							
11.11	30	39	.....	27	2	4	6	8	10	11¾	13¾	16	19¾	23	26½	29½	32½	35¼	38	40¼	42½	44¾						
11.66	36	19	24	39	1¾	3¾	5¾	7½	9½	11¼	13¼	15¾	18¾	22	25¼	28½	31¼	34	36½	39	41¼	43½						
12.00	36	39	.....	30	1¾	3¾	5½	7¼	9¼	11	12¾	15	18¼	21½	24¾	27¾	30½	33¼	35¾	38	40¼	42½	44¾					
13.12	36	19	27	39	1½	3½	5¼	6¾	8½	10¼	11¾	13½	16¾	20	22¾	25¾	28¼	31	33¼	35¾	37¾	40	42	43¾				
13.33	48	33	.....	36	1½	3¼	5	6½	8¼	10	11½	13¼	16½	19½	22½	25½	28	30½	33	35¼	37½	39½	41½	43¼	46¾	49¼	52¼	
13.71	48	21	27	45	1½	3¼	4¾	6½	8	9¾	11¼	13	16	19	22	24¾	27¼	30	32¼	34½	36½	38¾	40¾	42½	45¾	49	51½	

Approximate Angle in Degrees for setting Milling Machine Table.

These tables are of special convenience for quickly setting the machine with proper change gears when the angle of spiral and the diameter of a piece of work are known. For example: To cut a drum cam 2″ diameter, 28° angle: Follow down the 2″ column to the nearest angle, 27¾, and the change gears are 36, 39, and 30.

See pages 65 - 66 for lead and angle formulae

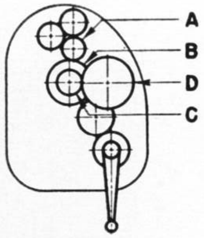
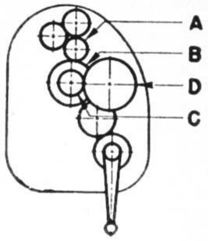


TABLE OF CHANGE GEARS, APPROXIMATE ANGLES, AND ENGLISH LEADS FOR CUTTING SPIRALS—(Concluded)

Lead of Spiral Inches	A	B	C	D	DIAMETER OF WORK																							
	Driven	Driver	Driven	Driver	⅛ In.	¼ In.	⅜ In.	½ In.	⅝ In.	¾ In.	⅞ In.	1 In.	1¼ In.	1½ In.	1¾ In.	2 In.	2¼ In.	2½ In.	2¾ In.	3 In.	3¼ In.	3½ In.	3¾ In.	4 In.	4½ In.	5 In.	5½ In.	6 In.
15.24	45	17	19	33	1½	3	4½	5¾	7¼	8¾	10¼	11¾	14½	17¼	20	22½	25	27¼	29½	31¾	34	35¾	37¾	39½	42¾	46	48½	51
15.56	42	36	.....	27	1¼	2¾	4¼	5¾	7¼	8¾	10	11½	14¼	17	19½	22	24½	27	29	31¼	33¼	35¼	37	39	42¼	45¼	48	50½
15.75	42	24	27	30	1¼	2¾	4¼	5½	7	8½	9¾	11¼	14	16¾	19¼	21¾	24¼	26½	28¾	31	33	35	36¾	38½	42	45	47½	50
16.87	45	24	27	30	1¼	2½	4	5¼	6¾	7¾	9¼	10½	13¼	15¾	18¼	20½	22¾	25	27	29¼	31¼	33¼	35	36½	39¾	43	45¾	48¼
17.14	36	39	.....	21	1¼	2½	4	5¼	6½	7¾	9	10¼	13	15½	17¾	20¼	22¼	24¾	26¾	29	30¾	32¾	34½	36	39½	42½	45¼	47¾
18.75	45	36	.....	24	1	2¼	3½	4¾	6	7¼	8¼	9½	12	14¼	16¼	18½	20¾	22¾	25	26¾	28½	30¼	32	33¾	37	39¾	42¾	45
19.29	45	21	27	30	1	2¼	3½	4½	5¾	7	8	9¼	11½	13¾	16	18¼	20¼	22¼	24	26	28	29¾	31½	33	36¼	38¾	42	44½
19.59	48	21	36	42	1	2¼	3¼	4½	5¾	6¾	8	9¼	11½	13½	15¾	18	20	22	23¾	25¾	27½	29¼	31	32¾	35¾	38¾	41½	44
19.69	51	19	33	45	1	2¼	3¼	4½	5¾	6¾	8	9	11½	13½	15¾	17¾	20	21¾	23¾	25½	27½	29¼	31	32½	35¾	38½	41¼	43¾
21.43	45	36	.....	21	1	2	3¼	4¼	5¼	6¼	7½	8½	10½	12½	14½	16½	18½	20¼	22	23¾	25½	27¼	29	30¼	33½	36¼	38¾	41¼
22.50	45	36	.....	20	1	2	3	4	5	6	7	8	10	12	13¾	15¾	17½	19¼	21	22¾	24½	27	27¾	29¼	32¼	35	37½	40
23.33	42	36	.....	18	1	2	3	4	5	5¾	6¾	7¾	9¾	11½	13¼	15¼	17	18¾	20¼	22	23½	25¼	27	28¼	31¼	34	36¾	39
26.25	45	30	42	24	1	1¾	2¾	3½	4¼	5	6	7	8½	10¼	12	13½	15	16¾	18¼	19¾	21¼	22¾	24¼	25½	28¼	31	33¼	35¾
26.67	48	36	.....	18	¾	1¾	2¾	3½	4¼	5	6	6¾	8½	10	11¾	13¼	14¾	16½	18	19½	21	22¼	23¾	25¼	28	30½	33	35¼
28.00	48	30	42	24	¾	1¾	2½	3¼	4	4¾	5¾	6½	8	9½	11¼	12¾	14¼	15¾	17¼	18¾	20	21½	22¾	24	26¾	29¼	31¾	34
30.88	45	36	42	17	¾	1½	2¼	3	3¾	4½	5	5¾	7¼	8¾	10	11½	13	14¼	15½	17	18½	19½	21	22	26	27	29¼	31½
31.50	45	30	42	20	¾	1½	2¼	3	3½	4¼	5	5¾	7¼	8½	10	11¼	12¾	14	15¼	16½	18	19¼	20½	21¾	24¼	26½	28¾	31
36.00	51	30	36	17	½	1¼	2	2½	3¼	3¾	4½	5	6¼	7½	8¾	10	11	12¼	13½	14¾	16	17	18¼	19¼	21½	23½	25¾	27¾
41.14	48	21	36	20	½	1	1¾	2¼	2¾	3¼	4	4½	5½	6½	7¾	8¾	9¾	10¾	11¾	13	14	15	16	17	19	21	22¾	24½
45.00	55	22	36	20	½	1	1½	2	2½	3	3½	4	5	6	7	8	9	10	11	11¾	12¾	13¾	14¾	15½	17½	19¼	21	22¾
48.00	48	21	42	20	½	1	1½	2	2½	3	3¼	3¾	4¾	5½	6½	7½	8½	9¼	10¼	11¼	12	13	13¾	14½	16½	18	19¾	21½
51.43	48	21	45	20	½	¾	1½	1¾	2¼	2¾	3	3½	4½	5¼	6	7	7¾	8¾	9½	10½	11¼	12	12¾	13¾	14¾	17	18½	20
60.00	60	21	42	20	½	¾	1¼	1½	2	2¾	2½	3	3¾	4½	5¼	6	6¾	7½	8¼	9	9½	10¼	11	11¾	13¼	14¾	16	17½
63.00	51	20	42	17	¼	¾	1	1½	1¾	2¼	2½	2¾	3½	4¼	5	5¾	6½	7	7¾	8½	9¼	10	10½	11¼	12¾	14	15¼	16¾
65.00	60	20	39	18	¼	¾	1	1½	1¾	2	2½	2¾	3½	4¼	4¾	5½	6¼	7	7½	8¼	9	9½	10¼	11	12¼	13½	15	16¼
70.00	60	20	42	18	¼	¾	1	1¼	1½	2	2¼	2½	3¼	3¾	4½	5¼	5¾	6½	7	7¾	8¼	9	9½	10¼	11½	12¾	13¾	15
72.00	51	20	48	17	¼	½	1	1¼	1½	2	2¼	2½	3	3¾	4¼	5	5½	6¼	6¾	7½	8	8¾	9¼	10	11	12¼	13½	14¾
75.00	55	22	51	17	¼	½	1	1¼	1½	1¾	2	2½	3	3½	4¼	4¾	5½	6	6½	7¼	7¾	8¼	9	9½	10¾	11¾	13	14
80.00	51	18	48	17	¼	¼	¾	1¼	1½	1¾	2	2¼	2¾	3¼	4	4½	5	5½	6¼	6¾	7¼	7¾	8½	9	10½	11	12¼	13¼
85.00	60	18	51	20	¼	½	¾	1	1¼	1½	1¾	2	2¾	3¼	3¾	4¼	4¾	5¼	5¾	6¼	6¾	7¼	8	8½	9½	10½	11½	12½
90.00	60	17	51	20	¼	½	¾	1	1¼	1½	1¾	2	2½	3	3½	4	4½	5	5½	6	6½	7	7½	8	9	10	10¾	11¾
100.00	60	17	51	18	....	½	¾	1	1¼	1½	1½	1¾	2¼	2¾	3¼	3½	4	4½	5	5½	5¾	6¼	6¾	7¼	8	9	9¾	10¾
107.80	60	17	55	18	....	½	¾	¾	1	1¼	1½	1¾	2	2½	3	3¼	3¾	4¼	4½	5	5½	5¾	6¼	6¾	7½	8¼	9	10



ENGLISH LEADS AND CHANGE GEARS FOR MILLING SPIRAL END MILLS

Set Machine Table to Angle of Approximately 20 Degrees

Diameter of Mill, Inches	Lead in Inches	Driven A	Driver B	Driven C	Driver D
⅜	3.24	27	33	19	48
½	4.32	36	33	19	48
⅝	5.40	45	33	19	48
¾	6.48	42	27	20	48
⅞	7.56	42	22	19	48
1	8.64	42	27	20	36
1⅛	9.72	45	27	21	36
1¼	10.79	36	20	27	45
1⅜	11.87	36	21	27	39
1½	12.94	22	45		17
1¾	15.11	48	22	27	39
2	17.26	51	19	27	42
2¼	19.41	33	36	.	17
2½	21.58	51	20	33	39
2¾	23.73	55	17	22	30
3	25.88	55	17	36	45
3¼	28.05	51	30	33	20
3½	30.22	51	30	48	27
3¾	32.38	51	27	36	21
4	34.53	51	24	39	24

ENGLISH LEADS AND CHANGE GEARS FOR MILLING SPIRAL MILLING CUTTERS

Set Machine Table to Angle of Approximately 25 Degrees

Diameter of Mill, Inches	Lead in Inches	Driven A	Driver B	Driven C	Driver D
½	3.37	27	33	21	51
⅝	4.22	27	24	18	48
¾	5.05	30	33	20	36
⅞	5.89	33	36	27	42
1	6.74	39	27	21	45
1¼	8.42	48	19	17	51
1½	10.11	42	22	27	51
1¾	11.79	42	19	42	45
2	13.47	36	21	33	42
2¼	15.16	48	19	27	45
2½	16.84	48	19	30	45
2¾	18.53	42	17	36	48
3	20.20	60	27	30	33
3¼	21.90	48	19	39	45
3½	23.58	48	19	42	45
3¾	25.26	48	33	. .	19
4	26.95	42	33	36	17
4¼	28.63	51	19	48	45
4½	30.32	48	30	36	19
4¾	32.00	48	21	42	30
5	33.69	45	33	42	17
5¼	35.37	48	30	42	19
5½	37.06	45	30	42	17
5¾	38.76	45	22	36	19
6	40.43	42	22	36	17

TABLE OF TANGENTS

(Natural Tangents at Intervals of ¼°)

Degrees	Tangent	Degrees	Tangent	Degrees	Tangent	Degrees	Tangent	Degrees	Tangent	Degrees	Tangent	Degrees	Tangent
0°	.0000	**13°**	.2309	**26°**	.4877	**39°**	.8098	**52°**	1.280	**65°**	2.145	**78°**	4.705
¼	.0044	13¼	.2355	26¼	.4931	39¼	.8170	52¼	1.292	65¼	2.169	78¼	4.808
½	.0087	13½	.2401	26½	.4986	39½	.8243	52½	1.303	65½	2.194	78½	4.915
¾	.0131	13¾	.2447	26¾	.5040	39¾	.8317	52¾	1.315	65¾	2.220	78¾	5.027
1°	.0175	**14°**	.2493	**27°**	.5095	**40°**	.8391	**53°**	1.327	**66°**	2.246	**79°**	5.145
1¼	.0218	14¼	.2540	27¼	.5150	40¼	.8466	53¼	1.339	66¼	2.273	79¼	5.267
1½	.0262	14½	.2586	27½	.5206	40½	.8541	53½	1.351	66½	2.300	79½	5.396
1¾	.0306	14¾	.2633	27¾	.5261	40¾	.8617	53¾	1.364	66¾	2.328	79¾	5.530
2°	.0349	**15°**	.2680	**28°**	.5317	**41°**	.8693	**54°**	1.376	**67°**	2.356	**80°**	5.671
2¼	.0393	15¼	.2726	28¼	.5373	41¼	.8770	54¼	1.389	67¼	2.385	80¼	5.820
2½	.0437	15½	.2773	28½	.5430	41½	.8847	54½	1.402	67½	2.414	80½	5.976
2¾	.0480	15¾	.2820	28¾	.5486	41¾	.8925	54¾	1.415	67¾	2.444	80¾	6.140
3°	.0524	**16°**	.2867	**29°**	.5543	**42°**	.9004	**55°**	1.428	**68°**	2.475	**81°**	6.314
3¼	.0568	16¼	.2915	29¼	.5600	42¼	.9083	55¼	1.442	68¼	2.507	81¼	6.497
3½	.0612	16½	.2962	29½	.5658	42½	.9163	55½	1.455	68½	2.539	81½	6.691
3¾	.0655	16¾	.3010	29¾	.5716	42¾	.9244	55¾	1.469	68¾	2.572	81¾	6.897
4°	.0699	**17°**	.3057	**30°**	.5774	**43°**	.9325	**56°**	1.483	**69°**	2.605	**82°**	7.115
4¼	.0743	17¼	.3105	30¼	.5832	43¼	.9407	56¼	1.497	69¼	2.639	82¼	7.348
4½	.0787	17½	.3153	30½	.5890	43½	.9490	56½	1.511	69½	2.675	82½	7.596
4¾	.0831	17¾	.3201	30¾	.5949	43¾	.9573	56¾	1.525	69¾	2.711	82¾	7.861
5°	.0875	**18°**	.3249	**31°**	.6009	**44°**	.9657	**57°**	1.540	**70°**	2.748	**83°**	8.144
5¼	.0919	18¼	.3298	31¼	.6068	44¼	.9742	57¼	1.555	70¼	2.785	83¼	8.449
5½	.0963	18½	.3346	31½	.6128	44½	.9827	57½	1.570	70½	2.824	83½	8.777
5¾	.1007	18¾	.3395	31¾	.6188	44¾	.9913	57¾	1.585	70¾	2.864	83¾	9.131
6°	.1051	**19°**	.3443	**32°**	.6249	**45°**	1.000	**58°**	1.600	**71°**	2.904	**84°**	9.514
6¼	.1095	19¼	.3492	32¼	.6310	45¼	1.009	58¼	1.616	71¼	2.946	84¼	9.931
6½	.1139	19½	.3541	32½	.6371	45½	1.018	58½	1.632	71½	2.989	84½	10.385
6¾	.1184	19¾	.3590	32¾	.6432	45¾	1.027	58¾	1.648	71¾	3.033	84¾	10.883
7°	.1228	**20°**	.3640	**33°**	.6494	**46°**	1.036	**59°**	1.664	**72°**	3.078	**85°**	11.430
7¼	.1272	20¼	.3689	33¼	.6556	46¼	1.045	59¼	1.681	72¼	3.124	85¼	12.035
7½	.1317	20½	.3739	33½	.6619	46½	1.054	59½	1.698	72½	3.172	85½	12.706
7¾	.1361	20¾	.3789	33¾	.6682	46¾	1.063	59¾	1.715	72¾	3.221	85¾	13.457
8°	.1405	**21°**	.3839	**34°**	.6745	**47°**	1.072	**60°**	1.732	**73°**	3.271	**86°**	14.301
8¼	.1450	21¼	.3889	34¼	.6809	47¼	1.082	60¼	1.750	73¼	3.323	86¼	15.257
8½	.1495	21½	.3939	34½	.6873	47½	1.091	60½	1.768	73½	3.376	86½	16.350
8¾	.1539	21¾	.3990	34¾	.6937	47¾	1.101	60¾	1.786	73¾	3.431	86¾	17.610
9°	.1584	**22°**	.4040	**35°**	.7002	**48°**	1.111	**61°**	1.804	**74°**	3.487	**87°**	19.081
9¼	.1629	22¼	.4091	35¼	.7067	48¼	1.120	61¼	1.823	74¼	3.546	87¼	20.819
9½	.1673	22½	.4142	35½	.7133	48½	1.130	61½	1.842	74½	3.606	87½	22.904
9¾	.1718	22¾	.4193	35¾	.7199	48¾	1.140	61¾	1.861	74¾	3.668	87¾	24.452
10°	.1763	**23°**	.4245	**36°**	.7265	**49°**	1.150	**62°**	1.881	**75°**	3.732	**88°**	28.636
10¼	.1808	23¼	.4296	36¼	.7332	49¼	1.161	62¼	1.901	75¼	3.798	88¼	32.730
10½	.1853	23½	.4348	36½	.7400	49½	1.171	62½	1.921	75½	3.867	88½	38.188
10¾	.1899	23¾	.4400	36¾	.7467	49¾	1.181	62¾	1.942	75¾	3.938	88¾	45.829
11°	.1944	**24°**	.4452	**37°**	.7536	**50°**	1.192	**63°**	1.963	**76°**	4.011	**89°**	57.29
11¼	.1989	24¼	.4505	37¼	.7604	50¼	1.202	63¼	1.984	76¼	4.087	89¼	76.39
11½	.2035	24½	.4557	37½	.7673	50½	1.213	63½	2.006	76½	4.165	89½	114.59
11¾	.2080	24¾	.4610	37¾	.7743	50¾	1.224	63¾	2.028	76¾	4.247	89¾	229.17
12°	.2126	**25°**	.4663	**38°**	.7813	**51°**	1.235	**64°**	2.050	**77°**	4.332	**90°**	
12¼	.2171	25¼	.4716	38¼	.7883	51¼	1.246	64¼	2.073	77¼	4.419		
12½	.2217	25½	.4770	38½	.7954	51½	1.257	64½	2.097	77½	4.511		
12¾	.2263	25¾	.4823	38¾	.8026	51¾	1.269	64¾	2.120	77¾	4.606		

ORDERING REPAIR PARTS

You will receive quicker service when ordering repair parts if you will adhere to the following procedure:

1. **State amount wanted.**

2. **Give part number and name or description of part, and where obtained.**
    - (*a*) Parts catalog.
    - (*b*) Part number stamped on part.
    - (*c*) Prior invoice.

3. **Give complete serial number of machine.** The serial number will be found stamped in two places: Horizontal Machines, on the face of the column near the spindle, and front of the table near the right hand end. Vertical Machines, top of the scraped bearing for the knee and front of the table near the right hand end.

4. **Specify each individual piece required.** If only certain parts of a unit are required, never use the word "complete"; it always raises the question as to how much of the unit to supply. In some cases, due to the nature of the parts, it will be less costly to you for us to supply additional related pieces, especially if part wanted is obsolete.

5. **Specify how and where to ship.** Do not say "Ship quickest way". Be definite and state the agency desired, that is:—Air Mail, Parcel Post, Special Delivery, Express, Motor Freight, Rail Freight, etc.

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CINCINNATI

MILLING MACHINE DIVISION

THE CINCINNATI MILLING MACHINE CO.
CINCINNATI 9 OHIO

MILLING MACHINES

HORIZONTAL KNEE & COLUMN

VERTICAL KNEE & COLUMN

HORIZONTAL & VERTICAL BED TYPE

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Products of the Milling Machine Division of The Cincinnati Milling Machine Co. are listed and symbolized here.

Products of The Cincinnati Milling Machine Co.'s other divisions include a complete line of centertype grinding machines, centerless grinding machines, roll grinding machines, surface grinding machines, chucking grinding machines, micro-centric grinding machines, special grinding machines, heat treating machines, metal forming machines, broaching machines, special machine tools and complete production lines, special machinery, cutting fluids and precision grinding wheels.

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